Table 1-5 (Continued)

Item	No Action Alternative	Green Book Proposal	DOI Proposal (Both Options)	Laguna Proposal	Anaconda Proposal	Preferred Alternative
Radiological Particulates	S - 4 F - Monthly P - U(Natural), Ra-226, Po-210, Th-230 D - In Perpetuity	S - 4 F - Monthly P - Same as No Action D - During reclamation and 3 years thereafter	S - 5 F - Monthly P - Same as No Action D - During reclamation and a minimum of 3 years thereafter	S - 4 F - Monthly P - Same as No Action D - 1 Year Minimum	S - 5 F - Quarterly P - Same as No Action D - During reclamation and 3 years there-after	S - 5 F - Monthly P - U(Natural), Ra-226, Po-210, Th-230 D - During reclamation and a minimum of 3 years there-after
Non-Radiological Particulates	S - 4 F - Monthly P - Total Suspended Particulates (TSP) D - In Perpetuity	S - 4 F - Monthly P - TSP D - During reclamation and 3 years thereafter	S - 5 F - Monthly P - TSP D - During reclamation and a minimum of 3 years thereafter	S - 4 F - Monthly P - TSP D - 1 Year Minimum	S - 5 F - Quarterly P - TSP D - During reclamation and 3 years there-after	S - 4 F - Monthly P - TSP D - During reclamation and a minimum of 3 years there-after
Gamma Radiation	S - Each reclaimed waste dump F - Once P - Ground survey of gamma radiation D - In Perpetuity	S - Each reclaimed F - Once P - Same as No Action D - During reclamation and 3 years thereafter	S - Each waste dump and selected reclaimed areas F - As needed P - Ground survey plus final aerial survey D - Before seeding and once after reclamation is completed	S - All reclaimed areas F - As needed P - Same as No Action D - Prior to soil placement	S - Each reclaimed area F - Once P - Same as No Action D - During reclamation and 3 years there-after	S - Each waste dump and selected reclaimed areas F - As needed P - Ground survey plus final aerial survey D - Before seeding and once after reclamation is completed.
Radon Gas	S - 4 F - Monthly P - Rn-222 (pCi/l) D - In Perpetuity	S - 4 F - Monthly P - Rn-222 (pCi/l) D - During reclamation and 3 years thereafter	S - 5 F - Monthly P - Rn-222 (pCi/l) D - A minimum of 3 years following reclamation	S - 4 F - Monthly P - Rn-222 (pCi/l) D - 1 Year Minimum	S - 5 F - Monthly P - Rn-222 (pCi/l) D - During reclamation and 3 years there-after	S - 5 F - Monthly P - Rn-222 (pCi/l) D - A minimum of 3 years following reclamation
Radon Exhalation	S - 4 F - Monthly P - pCi Rn-222/m^2-sec. D - In Perpetuity	S - 4 F - Monthly P - pCi Rn-222/m^2-sec. D - During reclamation and 3 years thereafter	S - 5 F - Monthly P - pCi Rn-222/m^2-sec. D - A minimum of 3 years following reclamation	Not proposed	Not proposed	S - 5 F - Monthly P - pCi Rn-222/M^2-sec. D - A minimum of 3 years following reclamation
Radionuclide and Heavy Metal Uptake Into Vegetation[a]	S - Each reclaimed waste dump F - Once P - U(Natural), Ra-226, Po-210, Th-230, Se, V, As, Cu, Cd, Mo, Pb, Zn D - In Perpetuity	S - Each reclaimed F - Once P - Same as No Action D - During reclamation and 3 years thereafter	S - Transects on selected reclaimed waste dumps and all pit bottoms F - Annually P - Same as No Action D - A minimum of 10 years following reclamation	S - One grid on each 50 acres of reclaimed area F - Once P - Same as No Action D - 1 Year Minimum	S - One grid per reclaimed area F - Once P - Same as No Action D - During reclamation and 3 years there-after	S - Transects on selected reclaimed waste dumps and all pit bottoms F - Annually P - Same as No Action D - A minimum of 10 years following reclamation

Table 1-5 (Concluded)

Item	No Action Alternative	Green Book Proposal	DOI Proposal (Both Options)	Laguna Proposal	Anaconda Proposal	Preferred Alternative
Vegetation Success	S - None F - None P - None D - None	S - Each revegetated area and reference areas F - Annually after third year of reclamation P - Basal cover and production D - Starting the third year after the last seeding or reseeding effort and annually until the success criteria is met.	S - Transects on waste dumps, pit bottoms and off-site reference areas. F - Annually P - Density, frequency, foliar cover, basal cover and production D - Using the CSA Method, plant establishment would be considered successful when revegetated sites reach 90 percent of the parameters listed above of undisturbed reference areas but not sooner than 10 years following reclamation	S - Survey of staked grids on reclaimed areas (one grid per 50 acres) and comparison plots. F - Annually P - Vegetation types, density, percent cover D - Until sites reach 90 percent of the species density and percent cover of comparison plots	S - Each revegetated area and reference areas F - Annually after third year of reclamation P - Canopy cover and biomass productior D - Starting the third year after the last seeding or reseeding effort and annually until the success criteria is met	S - Transects on waste dumps, pit bottoms and off-site reference reference areas F - Annually P - Density, frequency, foliar over, basal cover, and production D - Using the CSA Method, plant establishment would be considered successful when revegetated sites reach 90 percent of the parameters listed above of undisturbed reference areas but not sooner than 10 years following reclamation
Soils	S - One composite sample on each reclaimed waste dump F - Once P - U(Natural), Ra-226, Th-230, As, Se, Mo, Pb, V, Cd, Zn D - In Perpetuity	S - Same as No Action F - Once P - Same as No Action D - During reclamation and 3 years thereafter	S - One grid per 50 acres on each waste dump and pit bottom F - Once prior to seeding P - Same as No Action plus Pb-210 D - Once prior to seeding	S - One grid per 50 acres on each reclaimed area F - Once P - Same as No Action plus Pb-210 D - 1 Year Minimum	S - Grids on reclaimed areas F - Once P - Same as No Action plus Pb-210 D - During reclamation and 3 years thereafter	S - One grid per 50 acres on each waste dump and pit bottom F - Once prior to seeding P - Same as No Action plus Pb-210 D - Once prior to seeding
Meteorology	S - 1 F - continuously P - Wind speed, wind direction D - In Perpetuity	S - 1 F - continuously P - Same as No Action D - During reclamation and 3 years thereafter	S - 3 F - Continuously P - Same as No Action D - A minimum of 3 years following reclamation	Not Proposed	S - 1 F - continuously P - Same as No Action D - During reclamation and 3 years thereafter	S - 3 F - Continuously P - Wind speed and direction D - A minimum of 3 years following reclamation
Ground Vibration	Not Proposed	Not Proposed	S - Variable F - Each blast P - Particle Velocity (inches/sec.) and airblast (dB) D - Until all blasting is completed	S - Variable F - Each blast P - Particle Velocity (inches/sec.) D - Until all blasting is completed	Not Proposed	S - Variable F - Each blast P - Particle Velocity (inches/sec.) and airblast (db) D - Until all blasting is completed

[a]/Although a fixed duration and list of parameters is indicated for the preferred Alternative, the monitor program could be modified to take into account parameters that are at baseline levels or show no increasing trends.

TABLE 1-6

SUMMARY OF IMPACTS

Item	No Action Alternative	Green Book Proposal	DOI Proposal (Both Options)	Laguna Proposal	Anaconda Proposal	Preferred Alternative
Blasting During Reclamation	No blasting proposed.	No blasting specifications proposed to control ground vibration and air blast effects. Possible damage to homes in Paguate Village.	For both options, DOI has proposed specifications to control ground vibration and air blast effects. No blast related damage expected.	Specifications proposed for limiting ground movement only. Air blast effects could result in broken windows and other minor damage.	No blasting proposed.	Specifications proposed to control ground vibration and airblast effects. No blast related damage expected.
Mineral Resources	Resources in the P15/17, NJ-45 and P-13 underground areas would remain accessible over the short-term. However, over time the workings would deteriorate making them unsafe and inaccessible. Gavilan Mesa would eventually collapse and bury the protore buttress at its base. Over a period of decades, normal erosion would cause a significant loss of all protore located outside the pits.	All mine entries would be sealed, making the underground resources inaccessible. Gavilan Mesa would eventually collapse and bury the protore buttress at its base. All other protore would be placed in the open pits and would not be lost to erosion.	Impacts would be the same as Green Book Proposal except that recontouring Gavilan Mesa would increase its stability and lessen the chance of it collapsing on the protore buttress.	For mine entries, the impacts would be the same as the Green Book Proposal. No additional buttress material would be placed at the base of Gavilan Mesa. Recovery of protore would be enhanced since the protore would be segregated by grade and the location plotted on maps for future reference.	For mine entries, the impacts would be the same as the Green Book Proposal. No additional buttress material would be placed at the base of Gavilan Mesa. For the short-term, recovery of protore would be enhanced since it would remain in place above ground. Over the long-term, protore would be subjected to erosion and lateral migration of the Rios Paguate and Moquino.	All mine entries would be sealed making the underground resources inaccessible. No additional buttress material would be placed at the base of Gavilan Mesa. All protore would be buried in the open pits and would not be subjected to erosio or lateral migration of the Rios Paguate and Moquino.
Highwall Stability	North and South Paguate pit highwalls would be stable. Sporadic rockfalls would occur. Gavilan Mesa could eventually fail. Lack of fencing on highwall crests would be hazardous.	North and South Paguate pit highwalls would be stable. Rockfall hazards reduced by by scaling. Gavilan Mesa could eventually fail. Lack of fencing on highwall crests would be hazardous.	North and South Paguate pit highwalls would be stable. Rockfall hazards reduced by scaling and highwall crests sloped 3:1 to prevent piping. Lack of fencing on highwall crests would be hazardous. Fencing of the North and South Paguate pit highwalls would limit access to the crest. Gavilan Mesa recontoured to increase stability.	North and South Paguate pit highwalls would be stable. The top 15 feet of all highwalls cut to a 45 degree slope and the soils of all highwalls sloped 3:1 to prevent piping and keep people back from edge of highwalls. Rockfall hazards reduced by scaling. Gavilan Mesa could eventually fail. North and South Paguate pit highwalls fenced to limit access to highwall crests.	Highwall crests would be scaled 10 feet back at 3:1 to prevent piping. No scaling is proposed so the potential of rockfalls would persist. Gavilan Mesa could eventually fail. The potential hazard for people falling off the highwalls would be the same as described under the No Action Alternative.	North and South Paguate pit highwalls would be stable The top 15 feet of all highwalls cut to a 45 degree slope and the soils on highwalls sloped 3:1 to prevent piping and keep people back from edge of highwalls. All highwalls would be scaled to reduce rockfalls and the North and South Paguate pit highwalls would be fenced to limit access to the highwall crests. Gavilan Mesa could eventually fail..
Waste Dump Stability	All 32 waste dumps would eventually undergo mass failure, resulting in blocked drainages, alteration of stream courses, increased stream sediment loads and decreased surface water quality.	Based on calculated safety factors, 13 waste dumps would be unstable over the long-term and 12 waste dumps would be marginally to probably stable over the long-term. The remaining dumps would be stable. Mass failure of the dumps that are less than fully stable would result in the same environmental consequences as the No Action Alternative.	FD-2, I and Y2 dumps would be probably stable. All other waste dumps would be stable.	FD-2 would be probably stable. All other waste dumps would be stable.	Based on calculated safety factors, 13 waste dumps steeper than 2:1 would be only marginally stable over the long-term and would eventually fail, resulting in the impacts described under the No Action Alternative. All other dumps sloped 3:1 would be stable.	FD-2 would be probably stable. All other waste dumps would be stable.
Subsidence	Ground above the P-10 decline could experience sudden and significant subsidence.	The P-10 decline would be backfilled and sealed, eliminating the subsidence hazard.	Same as Green Book Proposal.	Same as Green Book Proposal.	Same as Green Book Proposal.	The P-10 decline would be backfilled and sealed, eliminating any subsidence hazard.
Underground Openings	Unsealed underground openings would present physical and radiological hazards.	All openings would be sealed and all associated hazards eliminated.	Same as Green Book Proposal.	Same as Green Book Proposal.	Same as Green Book Proposal.	All openings would be sealed and all associated hazards eliminated.

TABLE 1-6 (Continued)

Item	No Action Alternative	Green Book Proposal	DOI Proposal (Both Options)	Laguna Proposal	Anaconda Proposal	Preferred Alternative
Post-Reclamation Radiological Impacts	For the period 1982 through 2072, mathematical models predict 15 radiation - induced fatalities for the population within a 50-mile radius of the minesite. Approximately 135,000 natural cancer deaths are predicted for the same time period.	After reclamation, lung cancer deaths would be 10 percent of the No Action Alternative. All other cancer deaths would be reduced to less than 0.1 percent of the No Action Alternative.	Same as Green Book Proposal.	Same as Green Book Proposal.	NOTE: Due to time contraints and complexity of analysis, post-reclamation radiological impacts were not calculated for this plan. However, DOI believes that the minimal soil cover on the protore piles, as specified by the 1985 Plan, would cause the minesite to revert to conditions approaching the No Action Alternative.	After reclamation, lung cancer deaths would be 10 precent of the No Action Alternative. All other cancer deaths would be reduced to less than 0.1 percent of the No Action Alternative.
Surface Water Quantity	Perpetual evaporative loss of 200 acre-feet per year from pit bottoms.	The evaporative loss would be the same as the No Action Alternative. One time loss of 3,000 to 4,000 acre-feet of water would saturate the pit backfill.	Evaporative loss would be minimal; one time loss of 3,000 to 4,000 acre-feet of water would saturate the pit backfill.	Same as DOI's Proposal.	The total evaporative losses from the reclaimed pit bottoms and the proposed North Paguate water storage reservoir would be greater than the perpetual 200 acre-feet per year of the No Action Alternative.	Evaporative loss would be minimal; one time loss of 3,000 to 4,000 acre-feet of water would saturate the pit backfill.
Surface Water Quality	Water quality in the Rio Paguate would decrease over time due to erosion of protore piles and waste dumps. Water ponded in the open pits would have elevated levels of virtually all constituents.	All protore would be buried in the pits eliminating impacts to surface water quality. Up to 200 acres of intermittent ponds in the pit bottoms would be saline and unproductive for livestock use. Water quality in the Rio Paguate downstream would improve over time.	All protore would be buried as in the Green Green Proposal. For the Monitor Option, any ponded water or saline soils would be eliminated by remedial action. For the Drainage Option, ponds or saline soils would not exist at all. In contrast with the Green Book Proposal, the pit bottoms would be assured of productive use for livestock. Water quality in the Rio Paguate downstream would improve over time.	Same as DOI's Proposal except ponded water would only exist for a short time after heavy storms. Water quality in the Rio Paguate would improve over time.	Water quality impacts from backfilling the Jackpile and South Paguate pits would be the same as described in the Green Book Proposal. Water quality in the Rio Paguate would decrease as a result of inflow from the North Paguate reservoir. Surface water quality would also be decreased over the long-term due to erosion of nearby protore and mine wastes into the river channels.	All protore would be buried in the pits. Ponded water or saline soils in the pit bottoms would be eliminated by additional backfill. Ponded water would only exist for a short time after heavy storms. Water quality in the Rio Paguate would improve over time.
Ground Water Quality	Ground water would double in conductivity as it flowed through mine materials.	There would be a temporary increase in TDS and heavy metals. Eventually, ground water in the pits would revert to a reducing condition and limit the leaching of backfill material.	For both options, the leaching effects would be the same as the Green Book Proposal. However, for the Monitor Option, ground water quality would be better than under Green Book Proposal due to reduced evapotranspiration from the pit bottoms. The Drainage Option would further reduce the likelihood of evapotranspiration from waterlogged soils.	Same as DOI's Monitor Option.	Same as Green Book Proposal	There would be a temporary increase in TDS and heavy metals. Eventually, ground water in the pits would revert to a reducing condition and limit the leaching of the backfill materials. Additional backfill would reduce evapotranspiration from the pit bottoms.
Ground Water Recharge and Flow in the Pits	Approximately 50 acres of ponds would exist in the pit areas. Ponds would have elevated levels of salts, radionuclides and minor elements which could have deleterious health effects if ingested by wildlife, livestock or humans.	Ground water would locally converge in the pit bottoms where water would be evaporated and salts retained in the soil. (Backfill levels higher than the Green Book proposed minimum would reduce the impacts of this recharge and flow pattern).	Recharge and flow would be similar to the natural pattern. The DOI Monitor Option would add backfill as needed to control ponding and saline soil. Under the Drainage Option, waters would not pond in pits and surface runoff would be directed to the Rio Paguate.	Same as DOI's Monitor Option.	Phreatophytes would be used to transpire ground water inflow to the Jackpile and South Paguate pits. The phreatophytes would eventually concentrate salts in the upper soil layers and make the pit bottoms uninhabitable for any plant species. Ground water flow into the North Paguate pit reservoir would mix with the diverted Rio Paguate and exit via surface flow and seepage.	Recharge and flow would be similar to the natural pattern. Backfill would be added as necessary to control ponded water and saline soil.

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TABLE 1-6 (Continued)

Item	No Action Alternative	Green Book Proposal	DOI Proposal (Both Options)	Laguna Proposal	Anaconda Proposal	Preferred Alternative
Arroyo Headcutting	Headcuts south of I, Y and Y2 dumps would continue to erode, migrate upstream and eventually cut into the dumps. This would increase the sediment load and TDS concentration in the Rio Paguate. The headcut west of FD-3 dump would move upstream by piping-induced erosion and breach the road and dam.	Armoring of the headcuts south of I, Y and Y2 dumps would initially slow erosion, but eventually the armoring would become ineffective due to siltation and bypassing. Erosion would continue with the same impacts as the No Action Alternative.	An improved, no-maintenance armoring system would be used to increase the long-term stability of all headcuts.	Same as DOI's Proposal except the arroyo west of FD-3 would be relocated and not need stabilization.	Same as Green Book Proposal.	An improved, no-maintenance armoring system would be used to increase the long-term stability of all headcuts.
Sedimentation in Paguate Reservoir	Sedimentation would continue at a rate of about 22 acre-feet per year, but would increase when dump slope failures occur and when headcuts and/or the Rio Moquino cut into dumps.	Reclamation measures would reduce the existing sedimentation rate.	Same as Green Book Proposal.	Same as Green Book Proposal.	Same as Green Book Proposal.	Reclamation measures would re- duce the existing sedimentati rate.
Stream Stabilization	The rivers could migrate laterally and remove significant amounts of protore or waste dump material resulting in increased TDS, heavy metals, and possibly radionuclide concentrations in the Rios Paguate and Moquino The Rio Moquino road crossing could be breached during high flows.	All waste dumps would be moved back 200 feet from the rivers, providing a buffer against lateral migration and bank caving. The road crossing could still be breached as in the No Action Alternative.	The potential for lateral migration and bank caving would be the same as the Green Book Proposal. A permanent cement base or floodproof bridge across the Rio Moquino would stabilize the road crossing and would reduce chances for vertical incision.	Waste dumps along the Rio Moquino would be pulled back 50 feet from the river and the dump toes armored with riprap for protection against erosion, flood events, and the subsequent water quality impacts described under the No Action Alternative. The riprap would have to be maintained to remain effective over the long-term. Due to evidence of little lateral migration of the Rio Paguate, all contaminated soils would be moved back only 100 feet from the river.	Protore and waste dump material would be moved back only 50 feet from the Rios Paguate and Moquino. Lateral migration of the rivers and subsequent bank caving could lead to increased TDS, heavy metal and possibly radionuclide concentrations.	<u>Preferred Alternative</u> <u>Option A</u>: All waste dumps wo be moved back 200 feet from t rivers, providing a buffer against lateral migration and bank caving and thus reducing the water quality impacts des cribed under the No Action Alternative. <u>Option B</u>: Waste dumps along the Rio Moquino would be pull back 50 feet from the river a the dump toes armored with riprap for protection against erosion, flood events and the subsequent water quality impacts described under the N Action Alternative. The ripr would have to be maintained t remain effective over the long-term. Due to evidence c little lateral migration of t Rio Paguate, all contaminatec soils would be moved back onl 100 feet from the river.
Waste Dump Slope Erosion	High erosion rates of 79 tons per acre per year would continue to add waste material to the rivers resulting in decreased surface water quality.	Mean total erosion would be reduced to 26 tons per acre per year. However, steep slopes would still have a high potential for gully erosion. Runoff chutes would fail and would result in extensive gullying.	For both options, mean total erosion would be 13 tons per acre per year. The 3:1 slopes would reduce the potential for gullying. Sediment generated from approximately two square miles would be released by the Drainage Option.	Same as DOI's Monitor Option.	Mean total erosion would be reduced to 21 tons per acre per year. Only those slopes at 3:1 would be resistant to gullying. Steeper slopes would have a high potential for gully erosion.	Mean total erosion would be : tons per acre per year. The slopes would reduce the poter tial for gullying.

TABLE 1-6 (Continued)

Item	No Action Alternative	Green Book Proposal	DOI Proposal (Both Options)	Laguna Proposal	Anaconda Proposal	Preferred Alternative
Air Quality	TSP levels could exceed Federal or State standards for short periods. Besides creating an aesthetic problem, the particulates could include radioactive elements from the protore piles. This could create a health hazard.	All protore would be buried eliminating any radiological particulate health hazard. TSP levels are expected to be within Federal and State standards.	Same as Green Book Proposal.	Same as Green Book Proposal.	The soil cover on protore piles would eliminate the radiological particulate hazard in the short-term. Over the long-term, this soil cover could erode and expose radiological materials. TSP levels are expected to be within Federal and State standards.	All protore would be buried eliminating any radiological particulate health hazard. TSP levels are expected to be withi Federal and State standards.
Soils	Erosion rates would be high and plant densities low. No topsoil borrow area would be needed.	Redistribution of soils and reclamation of the minesite would decrease erosion rates and increase vegetative cover. A 44-acre topsoil borrow area may be needed. Up to 200 acres of pit bottoms abandoned from productive use due to salt build-up.	Same as Green Book Proposal except the greater soil depths would require additional borrow areas. The deeper soil cover (18"-24") would also reduce the possibility of intermixing soils with backfill materials during surface preparation. Backfill would be added as necessary to prevent ponding and salt build-up.	Since the top layer of pit backfill would be Mancos Shale, there is a possibility of temporary saturation of the topsoil - shale interface resulting in upward migration of salts. These salts would inhibit plant growth. Three topsoil borrow areas would be required.	Same as Green Book Proposal except that up to 160-170 acres of pit bottoms abandoned from productive use due to salt build-up.	Redistribution of soils and reclamation of the minesite would decrease erosion and increase vegetative cover. Several borrow areas may be necessary to accommodate soils depths of 18"-24". The deeper soil cover would reduce the possibility of intermixing soi with backfill materials during surface preparation. Backfill would be added as necessary to prevent ponding and salt build-up.
Flora	Meager and scattered vegetative re-establishment would continue by secondary succession on habitable sites. Many disturbed areas would remain permanently barren and unprotected from erosion.	Revegetated sites with only 70 percent of the basal cover and production of adjacent native reference areas would be less productive than natural sites, less capable of supporting populations of native and domestic herbivores, and more open to surface soil loss from erosional processes.	Gentler (3:1) slopes with contour furrows would significantly enhance the opportunities for plant community establishment. Vegetative parameters of density, basal and foliar cover, diversity and production on reclaimed sites would be at least 90 percent of that found on reference areas. A 10-year monitoring period would be necessary to monitor natural fluctuations in plant growth, ensure that the revegetative success criteria is met and to be certain that the resulting plant communities would be self-sustaining over the long-term. Reclaimed plant communities would therefore be more comparable with natural communities in terms of vegetative diversity and production, soil retention and carrying capacity for native and domestic herbivores. Pit bottoms would be closed to livestock grazing permanently due to the uncertainties of predicting radionuclide and heavy metal uptake into plants. For the remainder of the minesite, livestock grazing would be prevented for 10 years.	Vegetative parameters of species density and cover would equal or exceed 90 percent of that found on reference areas. This reduced number of vegetative parameters and a 3-year monitoring period would not ensure that plant communities are viable and self-sustaining over the long-term.	For areas outside the pits, impacts would be the same as the Green Book Proposal. Phreatophytes and other plant species proposed for the Jackpile and South Paguate pits may not survive over the long-term due to surface salt build-up.	Gentler (3:1) slopes with contour furrows would significantly enhance the opportunities for plant community establishment. Vegetative parameters of density, basal and foliar cover, diversity and production on reclaimed sites would be at least 90 percent of that found on reference areas. A 10-year monitoring period would be necessary to monitor natural fluctuations in plant growth, ensure that the revegetative success criteria is met and to be certain that the resulting plant communities would be sel sustaining over the long-term. Reclaimed plant communities would therefore be more comparable with natural communities in terms of vegetative diversity and production, soil retention and carrying capacity for native and domest herbivores. Pit bottoms would be closed to livestock grazing permanently due to the uncertainties of predicting radionuclide and heavy metal uptake into plants. For the remainde of the minesite, livestock grazing would be prevented for 10 years.

TABLE 1-6 (Continued)

Item	No Action Alternative	Green Book Proposal	DOI Proposal (Both Options)	Laguna Proposal	Anaconda Proposal	Preferred Alternative
Fauna	Wildlife habitat would be poor and wildlife populations would be low.	Habitat improvements would lead to an increase in wildlife populations.	A greater improvement in habitat would result from the improved revegetation. A corresponding increase in wildlife populations would result.	Same as DOI's Proposal.	Impacts would be similar to Green Book Proposal. Additionally, the 30-40 acre water storage reservoir in North Paguate pit would initially attract waterfowl and provide for fish habitat. However, over the long-term, water quality in the reservoir would decline, making it unfit for wildlife and fish.	Improved wildlife habitat compared to the No Action Alternative with corresponding increas in wildlife populations.
Cultural Resources	No Impact. Anaconda would continue to control access.	The disturbance of additional archaeological sites is not anticipated. Areas of religious concern would be avoided during reclamation efforts. Upon completion of reclamation, access to archaeological sites and religious areas would be less controlled allowing more vandalism as well as easier access for religious purposes.	Same as Green Book Proposal.	Same as Green Book Proposal.	Same as Green Book Proposal.	The disturbance of additional archaeological sites is not anticipated. Areas of religious concern would be avoided during reclamation efforts. Upon completion of reclamation, access to archaeological sites and religious areas would be less controlled allowing more vandalism as well as easier access for religious purposes.
Visual Resources	Visual resource quality would remain poor.	Visual resource quality would be enhanced by reclamation.	Higher revegetation success criteria would enhance visual resource quality compared to the Green Book Proposal.	Same as DOI Proposal.	Visual impacts would be similar to Green Book Proposal. The North Paguate pit water reservoir would be an introduced landscape feature that would attract attention.	Higher revegetation success cri teria would enhance visual resource quality compared to the other proposals.
Socioeconomic Conditions	Unemployment levels at the Pueblo of Laguna would remain high and associated social problems would persist.	Reclamation would provide temporary employment and income. However, as reclamation progresses and the work force is reduced, unemployment would resume and associated social problems would reappear.	Same as Green Book Proposal.	Same as Green Book Proposal.	Same as Green Book Proposal.	Reclamation would provide temporary employment and income. However, as reclamation progresses and the work force is reduced, unemployment would resume and associated social problems would reappear.
Irreversible and Irretrievable Commitment of Resources	A perpetual evaporative loss of 200 acre-feet per year of surface water.	The evaporative loss would be the same as the No Action Alternative. A one-time loss of 3,000 to 4,000 acre-feet of water would resaturate pit backfill. Energy usage would be 292,000 kilowatt hours and 5.4 million gallons of fuel, respectively. Reclamation would require 201 man-years of labor.	One-time loss of 3,000 to 4,000 acre-feet of water would resaturate pit backfill. Energy usage for the Monitor Option would be 290,000 kilowatt hours and 5.3 million gallons of fuel; for the Drainage Option 290,000 kilowatt hours and 5.5 million gallons of fuel. Reclamation would require 198 (Monitor Option) and 203 (Drainage Option) man-years of labor.	One-time loss of 3,000 to 4000 acre-feet of water would resaturate pit backfill. Energy usage would be 292,000 kilowatt hours and 3.7 million gallons of fuel. Reclamation would require 137 man-years of labor.	Total evaporative losses from the reclaimed pit bottoms and the North Paguate pit reservoir would be greater than the 200 acre-feet per year of the No Action Alternative. Energy usage would be 292,000 kilowatt hours and 2.1 million gallons of fuel. Reclamation would require 77 man-years of labor.	One-time loss of 3000 to 4000 acre-feet of water would resaturate pit backfill. Energy usage would range from 290,000 to 292,000 kilowatt hours and from 3.7 to 5.3 million gallons of fuel. Reclamation would require 137 to 198 man-years of labor.
Total Non-Radiological (equipment use) Accidents During Reclamation	0	30.2	29.8 (Monitor Option) 30.5 (Drainage Option)	20.6	11.6	20.6 to 29.8

0400054

Chapter 2
affected environment

NTRODUCTION

his chapter describes the existing physical, biological and ocioeconomic conditions in and adjacent to the Jackpile-Paguate uranium ine. The information in this chapter provides the basis for the ssessment of impacts made in Chapter 3.

lap 1-2 in Chapter 1 shows the principal features of interest in and round the minesite. These features are also listed in Table 2-1. Table -2 defines terms that are used throughout this document. These lefinitions apply specifically to this EIS and should not be confused vith other definitions for these terms.

MINING OPERATIONS

Operations at the Jackpile-Paguate uranium mine were conducted from three open pits and nine underground mines. Open-pit mining was conducted predominantly with large front-end loaders and haul trucks. The overburden, consisting of topsoil, alluvium, shale and sandstone was blasted or ripped, removed from the open pits, and placed in waste dumps. The uranium ore was segregated according to grade and stockpiled for shipment to the mill. In the later years of mining, material conducive to plant growth was stockpiled for future reclamation. Ore-associated waste and some overburden was also placed in the mined-out areas of the pits as backfill.

Underground mining was conducted by driving adits, or declines, to the ore zones. Drifts were driven through the ore zone, and the ore removed by modified room-and-pillar methods. Ventilation holes were drilled to maintain a fresh air supply. Mine water was collected in sumps and pumped to ponds in the open pits. Waste rock was placed in waste dumps, and the ore was stockpiled for shipment to the mill.

Surface Disturbance

During the 29 years of mining activity, approximately 2,656 acres of natural ground were disturbed by mine operations, as indicated in Table 2-3 and on Visual A.

Open Pits

The Jackpile, North Paguate and South Paguate open pits make up about 40 percent of the total disturbed acreage at the minesite (Figure 2-1). Approximately 101 million tons (63.6 million cubic yards) of backfill, composed principally of ore-associated waste with some overburden, have been returned to the pits. Due to irregular topography, the pits vary in maximum depth as follows: Jackpile 625-feet deep; North Paguate-200 feet deep; and South Paguate-325 feet deep.

The most prominent features within the excavated pits are the pit walls (also called highwalls), which are composed principally of shale with some intermixed sandstone beds. The overall slope angle of the pit walls ranges between 49 and 55 degrees (Figure 2-2).

TABLE 2-1

PRINCIPAL FEATURES OF INTEREST IN AREA OF JACKPILE-PAGUATE URANIUM MINE

Feature	Description
Anaconda Mining Leases	Three leases totaling approximately 7,868 acres.
NM Highway 279	Realignment is being proposed to eliminate a hazardous section of this State highway that presently passes around the mine. This realignment is not part of the overall reclamation project.
Paguate Reservoir[a/]	Constructed south of the mine area in 1940, now almost completely silted in.
Rail Spur	Constructed by Anaconda on a right-of-way across Pueblo of Laguna land.
Rio Paguate and Rio Moquino	Small perennial rivers that join within the minesite for an average combined discharge of 1.2 cubic feet per second.
Village of Laguna	Laguna Indian village with 1,565 residents.
Village of Paguate	Laguna Indian village with 1,435 residents located approximately 1,000 feet from the mine.

Note: [a/] Paguate Reservoir is sometimes referred to as Quirk or Mesita Reservoir.

0400057

TABLE 2-2

TERMS USED IN THIS EIS

General Term	Definition	Components
Jackpile Sandstone	The ore-bearing unit at the Jackpile-Paguate uranium mine	Barren waste [less than .002 percent uranium (U_3O_8)][a]
		Ore-associated waste (.002 to .019 percent U_3O_8)[a]
		Protore (.02 to .059 percent U_3O_8--refer to Glossary)[a]
		Ore (greater than .06 percent U_3O_8)[a]
Overburden	Any material that overlies the ore-bearing unit	Topsoil, Alluvium, Mancos Shale, Tres Hermanos Sandstone, Dakota Sandstone
Soil	Material used as plant-growth medium during revegetation	Topsoil, Alluvium, Pulverized Tres Hermanos Sandstone

Note: [a]This percentage range applies to this EIS only--refer to the Mineral Resources section of this chapter for an explanation.

0400058

TABLE 2-3

JACKPILE-PAGUATE URANIUM MINE DISTURBED AREAS

Feature	Acres
Open Pits	
Jackpile	475
North Paguate	140
South Paguate	400
	1,015
Waste Dumps	
Jackpile area	718
North Paguate area	192
South Paguate area	356
	1,266
Protore Stockpiles	
Total mine area, excluding open pits	103
Topsoil Stockpiles	
TS-1	21
TS-2(A and B)	11
TS-3[a]	(19)
	32
Other Disturbed Areas	
Depleted ore stockpiles[b]	50
General area disturbance (includes buildings, parking lots)	66
Roads	88
Rail spur and miscellaneous areas	36
	240
TOTAL ACRES DISTURBED	2,656

Source: Anaconda Minerals Company 1982.

Notes: [a] Topsoil stockpile TS-3 is located on South Dump and therefore does not constitute additional acreage of disturbed natural ground.
[b] Refers to former stockpile areas in which the ore was either relocated to the open pits or shipped to the mill.

FIGURE 2-1 VIEW SOUTH THROUGH JACKPILE PIT

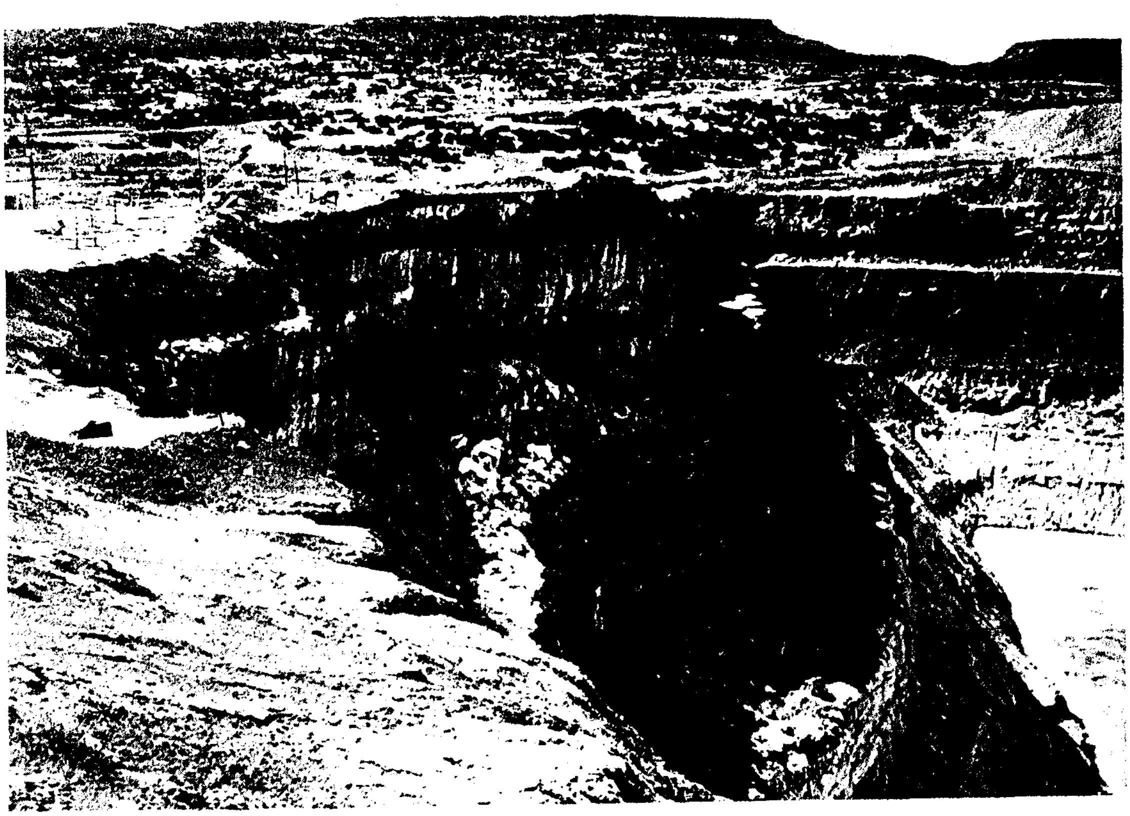

FIGURE 2-2 SOUTH PAGUATE PIT HIGHWALL

Water has collected in the lowest portions of the pits as a result of surface runoff, ground water recovery and water discharged from the underground operations (Figure 2-3). As of April 1984, water levels in the pits ranged between elevations of 5830' and 5959'.

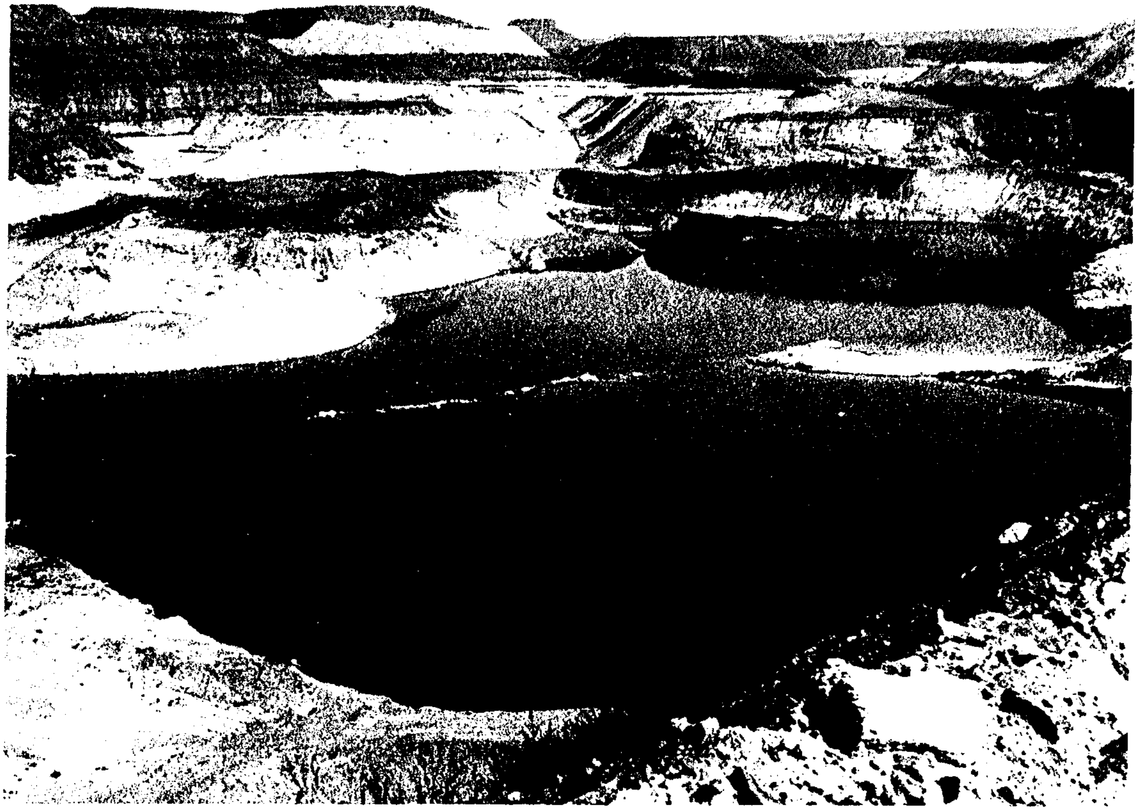

FIGURE 2-3 PONDING IN NORTH PAGUATE PIT

Waste Dumps

The minesite contains 32 waste dumps that make up about 48 percent of the disturbed area (Figure 2-4). The dumps are composed of Tres Hermanos Sandstone, Mancos Shale, Dakota Sandstone, and both barren and ore-associated Jackpile Sandstone. Characteristics of the dumps, including previous reclamation performed, are presented in Table 1-4 (Chapter 1).

Protore Stockpiles

Located outside and inside of the pits are 23 protore stockpiles (Figure 2-5 and Table 2-4). The protore that lies outside the pits covers approximately 100 acres and contains approximately 7.2 million cubic yards of material. Those stockpiles that lie inside the pits contain about 3.1 million cubic yards of matieral but do not constitute additional acreage of disturbed ground. The stockpiles are generally segregated according to grade, but some grade variation exists within each stockpile.

FIGURE 2-4 WASTE DUMPS ON NORTH SIDE OF MINE

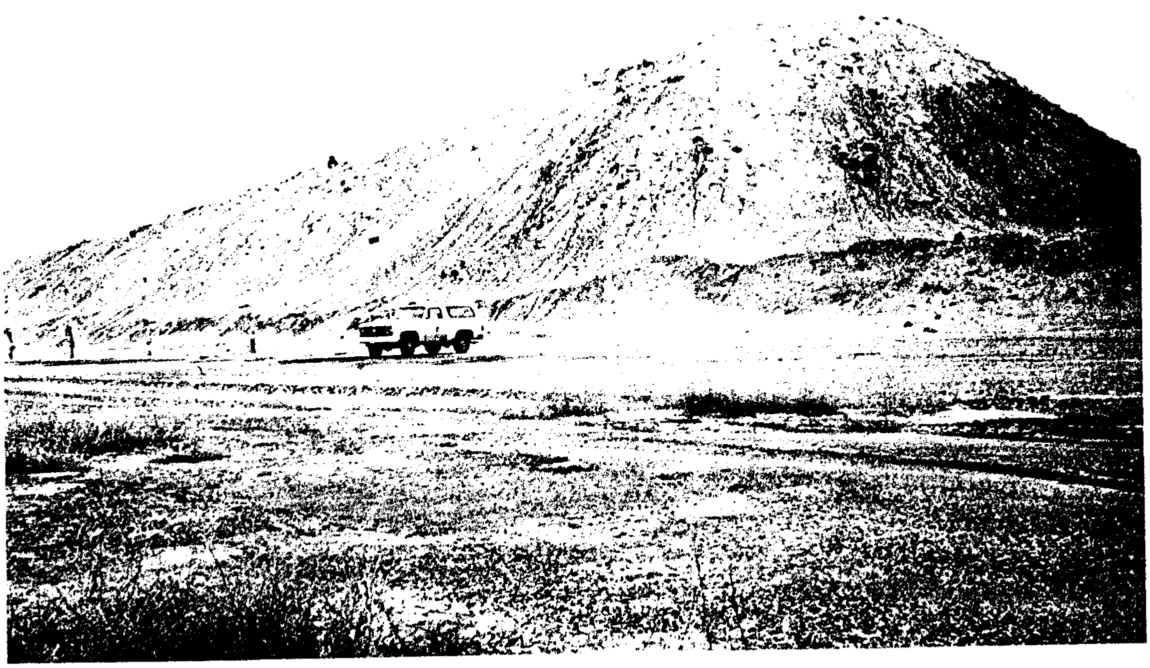

FIGURE 2-5 PROTORE STOCKPILE SP-1

TABLE 2-4

PROTORE STOCKPILES AT THE JACKPILE-PAGUATE URANIUM MINE

Area	Stockpile Designation	Volume (cubic yards)
Jackpile Mine Area	J-1	328,950
	J-1A[a]	
	J-1-A	1,673,500
	JLG	
	SP-1	353,700
	J-2	156,860
	SP-6-A	1,517,000
	SP-6-B	
	SP-17BC	18,100
	17-E[a]	660,000
North Paguate Mine Area	1-B	993,760
	1-E[a]	154,500
	2-E	255,400
	10-Dike	23,920
	SP-1	620,400
	SP-1-C	284,720
	SP-2-C	1,223,790
	SP-2-D	122,660
South Paguate Mine Area	1-D[a]	
	PLG	648,700
	PLG-1	
	4-1	154,800
	SP-1-A	1,161,830
TOTALS	23 stockpiles	10,352,590

Source: Stockpile designations and locations Anaconda Minerals Company 1982; volumetric calculations Anaconda 1982 and BLM 1984.

Note: [a] Stockpiles located within pits themselves.

Topsoil Stockpiles

During the later years of mining, all Tres Hermanos Sandstone and alluvium encountered during surface mining was stockpiled for future reclamation operations. These stockpiles contain approximately 3.1 million cubic yards of material (BLM 1984).

Surface Facilities

The minesite contains various buildings, structures and surface facilities which cover approximately 66 acres (Figure 2-6). Most of the major buildings are constructed on cement slabs with steel frames and sheet metal siding. Many have heating, sewage, electric and drinking water systems. The condition of the buildings varies considerably, but many are in good condition. A list of these facilities located on leases No. 1 (Jackpile) and No. 4 is shown in Table 2-5.

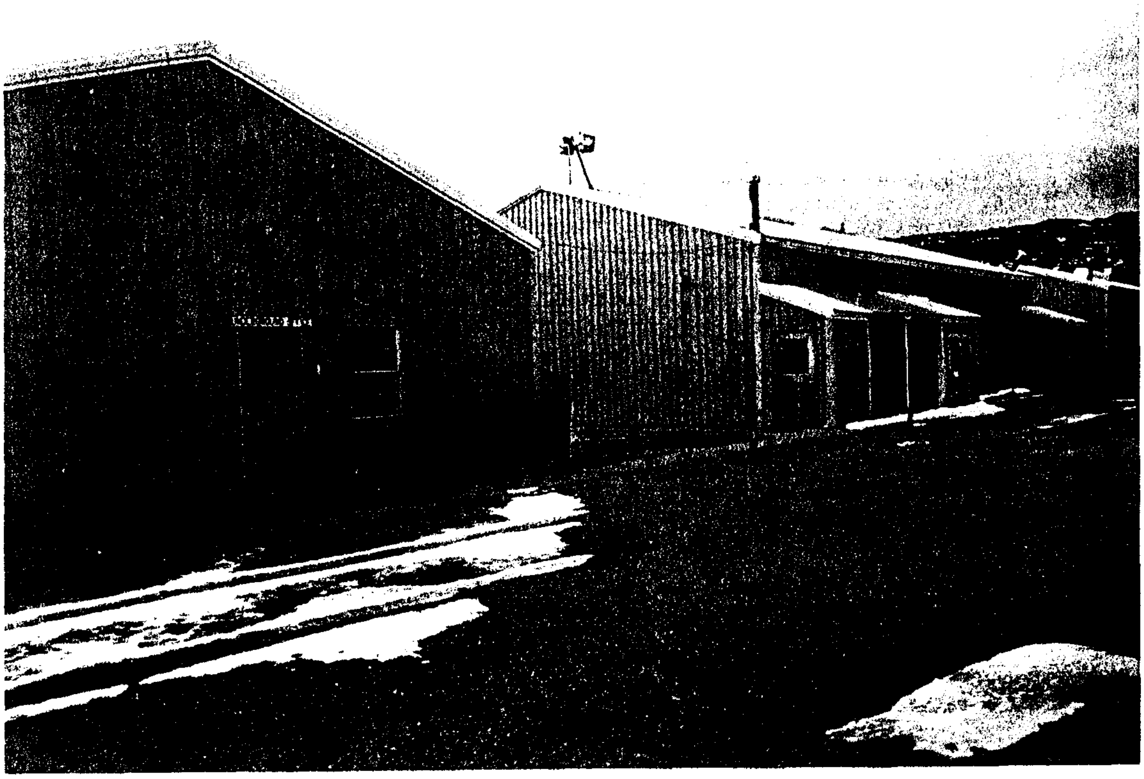

FIGURE 2-6 P-10 MINE BUILDINGS

The minesite also contains a rail spur that connects the site to the main east-west line of the Santa Fe Railroad, 5 miles south. The spur was used to transport ore from the mine to Anaconda's Bluewater Mill near Grants, New Mexico.

TABLE 2-5

STRUCTURES AND FACILITIES LOCATED ON LEASES NOS. 1 AND 4

Lease/Feature	Coverage
<u>Lease No. 1 (Jackpile)</u>	
Buildings-Structures	
1. Geology building	4,000 sq. ft.
2. School building	1,500 sq. ft.
3. Miners' training center	2,730 sq. ft.
4. Guardhouse (2)	144 sq. ft. each
5. Explosives magazines (3)	100 sq. ft; 1,200 sq. ft.; 180 sq. ft.
6. Maintenance and repair shop	7,000 sq. ft.
7. Repair and electrician's shop	1,260 sq. ft.
8. Welding shop	1,600 sq. ft.
9. Warehouse	3,600 sq. ft.
10. Change house	480 sq. ft.
11. Restroom	320 sq. ft.
12. Safety room and change room	1,116 sq. ft.
13. Mine engineering and housing repair shop	5,000 sq. ft.
14. Fuel service area (mine office) a. 2 ea. gasoline pumps b. Gasoline storage tanks	
15. Fuel service area (Hamilton) a. 2 ea. fuel pumps b. 2 ea. underground fuel storage tanks	
16. Surface mining main office	1,116 sq. ft
17. Truck parking lot (includes 20 service stands and 2 small buildings)	
18. Boundary fencing	approx. 14,850 linear ft.
19. Road culverts over Rios Moquino and Paguate (6 ea.)	
20. Concrete crossing (ford) over Rio Paguate near main gate	
Housing	
1. 7 houses	approx. 1,650 sq. ft. each
11 houses	approx. 1,250 sq. ft. each
2. Recreational facilities (includes tennis/basketball courts, misc. playground equipment)	
Utilities	
1. 5 wells, cased with pumps a. Jackpile No. 1 - Peerless vertical turbine pumps, electrical service (not activated), building b. Jackpile No. 2 - Reda submersible pump, electrical service (not activated), building c. Jackpile No. 3 - submersible pump, electrical service (not activated), building d. Jackpile No. 4 - submersible pump, electrical service (not activated), building e. Jackpile No. 5 - Jensen straight pumpjack, electrical service (not activated), building	
2. Water Distribution Systems and Water Storage Tanks a. 600 gallon (1 ea.) b. 800 gallon (1 ea.) c. 1,000 gallon (1 ea.) d. 2,000 gallon (1 ea.)	
3. Housing Sewage Disposal System and Lagoons—2-cell sewage lagoon (fenced)	
4. Powerlines a. Poles	
b. Wire line	approx. 16,000 linear ft.
c. Transformers	
5. 3-Phase Substation at Engineering Office	

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TABLE 2-5 (concluded)

Lease/Feature	Coverage
Lease No. 1 (Jackpile) (cont'd)	
Rail Spur	
Railroad spur from rail line (AT & SF) to mine- Materials: 90# rail, ties, hardware, ballast, turnouts and switches, bridge structure and culverts	approx. 5.4 miles long
Lease No. 4	
Buildings-Structures	
1. P-10 underground mine office	4,000 sq. ft.
2. P-10 change house	2,800 sq. ft.
3. P-10 equipment repair shop	1,850 sq. ft.
4. P-10 electric shop	1,900 sq. ft.
5. P-10 storage shed	150 sq. ft.
6. P-10 fenced storage yard	approx. 1.5 acres
7. Carpenter shop	2,520 sq. ft.
8. Paint shop	225 sq. ft.
9. Electric shop	2,520 sq. ft.
10. Welding shop	3,000 sq. ft.
11. Warehouse	10,800 sq. ft.
12. Rebuild shop	1,350 sq. ft.
13. Maintenance and repair shop	12,240 sq. ft.
14. Small storage shed	150 sq. ft.
15. Wash rack and associated buildings	306 sq. ft.
16. Garage	864 sq. ft.
17. Change house	936 sq. ft.
18. Conference hall and office	1,200 sq. ft.
19. Fuel service area, including:	
a. 2 gasoline pumps	
b. 1 diesel pump	
c. 3 fuel storage tanks	
20. Chain-link fenced shop storage yards (2)	approx. 1 to 1.5 acres ea.
21. Chain-link fenced warehouse storage yard (asphalt base)	approx. 1/4 acre
22. Guardhouse (2)	144 sq. ft each
23. Explosives magazine (2 ea.)	600 sq. ft.
24. Stock water tank (south of new shop well)	
Utilities	
1. 2 wells, cased with pumps	
a. P-10 well, submersible pump, electrical service, cover structure	
b. New shop well, submersible pump, electrical service, cover structure	
2. Water distribution systems and water storage tanks	
a. P-10 tank, approximately 1,000 gallon with support structure	
b. New shop tank, approximately 1,200 gallon with support structure	
3. Sewage disposal system and lagoons.	
a. P-10 with 3-cell lagoon (fenced)	
b. New shop system with 3-cell lagoon (fenced)	
4. Powerlines	
a. Poles	
b. Wire line	approx. 7,600 linear ft.
c. Transformers	

Source: Anaconda Minerals Co. 1984.

Note: All building areas are approximate.

0400066

Underground Disturbance

Mining was conducted in nine underground mines (Visual A). Five of these mines were permanently plugged and abandoned as part of normal mining operations. The remaining four were operating when overall mining operations were suspended, and each has been temporarily closed for safety (Figure 2-7). Table 2-6 briefly describes each mine.

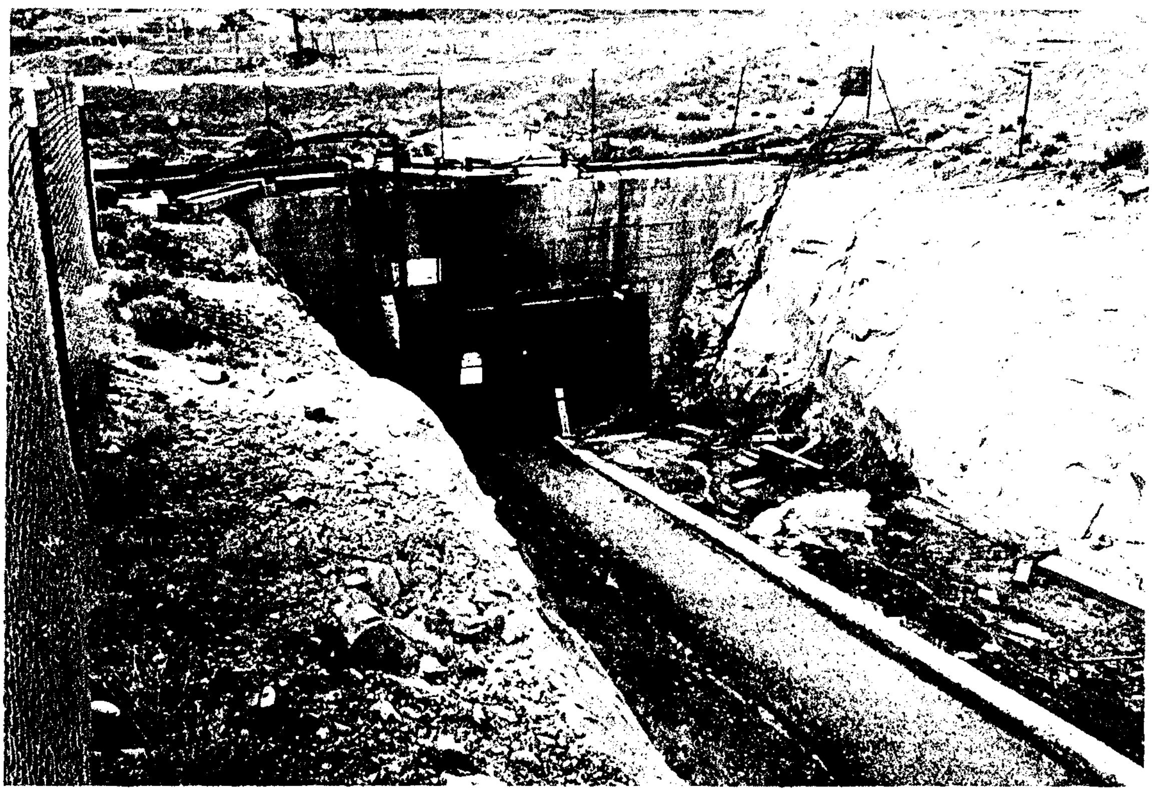


FIGURE 2-7 P-10 DECLINE -TEMPORARILY ABANDONED

Only the P-10 mine produced a substantial amount of water, and the water level has risen to render its workings inaccessible. The deposits at each of the mines, with the exception of NJ-45 and P-13, were mined as completely as the economics of the times would allow.

Previous Reclamation

Anaconda Minerals Co. began a limited reclamation program in 1976. The program consisted of returning most of the overburden removed during the stripping process to mined-out areas of the pits, clearing of stream channels, slope stabilization tests and revegetation of dumps. Each of these processes is described as follows.

TABLE 2-6

STATUS OF UNDERGROUND MINING OPERATIONS

ine	Description	Status
lpine	Small operation - access via 2 adits	Adits permanently plugged with waste
-1	Small operation - access via 2 adits -3 vent holes - used as an undergroundminer's training school	Adits and vent holes permanently plugged with waste
J-45	Small operation begun in 1981 - access via 3 adits from Jackpile pit - 2 vent holes - approximately 1/3 of ore removed	Adits and vent holes temporarily covered - mine workings relatively stable and assumed to be inaccessible
P-7	Large operation - access via P-10 underground drifts - 6 vent holes- vertical emergency escapeway into South Paguate pit	Vent holes temporarily covered - mine workings filled with water and inaccessible
P-9-2	Large operation - access via 5 adits -8 vent holes	Adits, majority of workings, and all but 1 vent hole mined through by advances of South Paguate pit - 1 vent hole open but covered
P-10	Large operation - access via 2,000-foot decline - 11 vent holes	Decline and vent holes temporarily covered - mine workings filled with water and inaccessbile
P-13	Small operation begun in 1981 - access via 2 adits from South Paguate pit - ore body not fully opened - very small percentage of ore removed	Adits and mine workings flooded with water and inaccessible
P 15/17	Large operation approved for development but never begun	No operations conducted
PW 2/3	Small operation - access via 2 adits from North Paguate pit - 2 vent adits into pit	All adits permanently covered with backfill (highwall buttress)
Woodrow	Small operation - vertical shaft with 2 working areas to mine vertical breccia pipe deposit - mining completed in 1956	Shaft backfilled from bottom to top

Source: Anaconda Minerals Company 1982.

Backfilling

During the later years of mining, some overburden was placed into the mined-out portions of the pits. The southern portion of the Jackpile pit and the South Paguate pit received most of this material. Backfilling was also performed for two possible routes for the realignment of State Highway 279. There were no requirements to keep records on the radiological content of the backfill material.

Stream Channel Modifications

In an effort to begin clearing waste from the Rio Moquino's floodplain, approximately 500,000 tons of material from waste dump U on the east side of the river were removed during the last year of mining operations.

Slope Stabilization Tests

Limited tests were performed on the slope of waste dump I to evaluate the ability of biodegradeable matting to inhibit erosion. Special reseeding techniques were performed on the slope of waste dump J. The matting and special reseeding techniques were unsuccessful.

Waste Dump Revegetation

The tops of 17 waste dumps were reclaimed between 1976 and 1979. The tops were contoured to a slight slope, water spreading berms were constructed, large boulders were pushed into piles, 18 to 24 inches of soil were spread, and the dumps were seeded. This work was performed on 18 percent of the disturbed area with varying degrees of success. Further details are provided in the Flora section of this chapter.

Monitoring

Anaconda has performed a comprehensive environmental monitoring program since 1977. The program is summarized in Table 2-7.

GEOLOGY

Physiography

The Jackpile-Paguate minesite is located in mesa and canyon country typical of much of the southeastern Colorado Plateau physiographic province. It is situated in a broad valley of northwest-dipping, sandstone-capped benches pierced by numerous basaltic volcanic necks that rise up to 1,000 feet above the surrounding terrain. Principal landscape components in the area are:

1. Sparsely vegetated, sandstone-capped, flat mesa tops;

2. Steep mesa slopes characterized by approximately 30-degree shale slopes and nearly vertical sandstone slopes, with basal talus from numerous rock falls;

TABLE 2-7

ANACONDA'S ENVIRONMENTAL MONITORING PROGRAM

Item	Monitoring Frequency	Monitoring Parameters	Number of Stations Monitored
Subsidence	Quarterly[a/]	Ground movement	89
Surface water	Monthly	29 chemical and radiological parameters[b/]	6
Ground water	Monthly	29 chemical and radiological parameters[b/]	3[c/]
Particulates (radiological)	Monthly	U-natural, Ra-226, Po-210 and Th-230	4
Particulates (non-radiological)	Monthly	Total particulates	4
Gamma	Once after topsoil application	Gamma radiation	100-meter grid on each waste dump
Radon concentration	Monthly	Rn-222	4
Radon exhalation	Twice after topsoil application	Radon release per unit area	100-meter grid on each waste dump
Vegetation	Once	Th-230, Ra-226, Po-210, uranium and radon	Each reclaimed waste dump
Vegetation	Variable	Density, diversity and basal cover	Each revegetated area
Soils	Once	11 chemical and radiological parameters	One composite sample on each reclaimed waste dump
Meteorology	Continuous	Wind speed and direction, temperature and precipitation	1

Notes: a/ On June 9, 1983, subsidence monitoring of P-13 and P-15/17 was discontinued because these mine workings were never developed. At the same time, the monitoring frequency for the P-10 and PW-2/3 mines was reduced to semi-annual.

b/ pH, conductivity, TDS, HCO_3, Cl, SO_4, Na, K, Ca, Mg, NO_3, F, SiO_2, Mn, As, Ba, Cd, Cr, Pb, Hg, Se, Cu, Fe, Zn, Mo, Ni, V, U, Ra-226.

c/ Sampling of the Old Shop Well was discontinued in May 1983. Sampling of the New Shop and #4 wells was discontinued in August 1983. A new ground water monitoring program using nine wells was started in September 1983.

0400070

3. Vegetated valley floors cut by numerous arroyos entrenched in fine-grained alluvium; and

4. Densely vegetated, major stream beds.

Prominent landforms of the mine area are: Gavilan Mesa to the east, North and South Oak Canyon Mesas and Oak Canyon to the south, and Black Mesa and numerous deep canyons to the west. Within the lease boundary, elevations range from 5,820 to 6,910 feet.

Stratigraphy

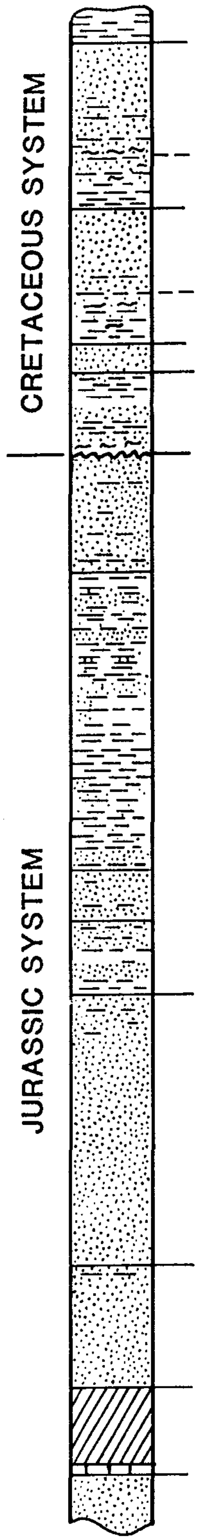
Sedimentary rocks exposed in the area of the minesite range in age from Late Triassic to Late Cretaceous. In addition, Tertiary age diabase dikes and sills and volcanic flow rocks are exposed near the minesite. A generalized stratigraphic column is given in Figure 2-8.

At the minesite, all of the rock units above the lower Mancos Shale have been eroded. The stratigraphy of the mine includes the Morrison Formation, Dakota Sandstone, Mancos Shale, Tertiary igneous dikes and Quaternary alluvium.

The Morrison Formation, locally 600 feet thick, consists of (in ascending order) the Recapture Member, the Westwater Canyon Member, the Brushy Basin Member, and the Jackpile Sandstone Member (Owen et al 1984). The Brushy Basin Member, which is exposed at the minesite, is composed of mudstones up to 350 feet thick with numerous interbedded thin sandstone lenses of restricted extent. The Jackpile Sandstone Member is the uranium mineralization host rock, and is grayish-white, fine- to medium-grained friable sandstone. The Jackpile Sandstone Member is locally more than 200 feet thick (Kittle 1963).

Unconformably overlying the Jackpile Sandstone is the Upper Cretaceous Dakota Sandstone. The Dakota Sandstone intertongues with the overlying lower Mancos Shale, thus creating a stacked series of marine sandstones and shales (Landis et al 1973) shown in Figure 2-8. The sandstones are generally grayish-orange, tan, or yellowish-gray in color, fine- to medium-grained, and have sharp upper contacts and gradational lower contacts (Schlee & Moench, 1963b). The lowermost Dakota unit, the Oak Canyon Member, also contains black shale interbeds, a basal conglomerate in many places, and an upper gray shale portion which has been mapped by some authors as a tongue of the Mancos Shale (Landis et al 1973). The tongues of the Mancos Shale consist of gray friable shale with sparce beds of yellowish-gray friable sandstone. This sequence of Dakota and Mancos intertongues is about 320 feet thick in the mine area.

Quaternary alluvium ranges from 0 to 60 feet thick along the Rios Paguate and Moquino, and is over 100 feet thick along the Rio San Jose (Lyford 1977). The alluvium is composed mostly of silt and fine- to medium-grained sand.



FORMATION	MEMBER	THICKNESS (feet)
Mancos	Main body	
Dakota	Two Wells Sandstone Tongue	60
Mancos	Whitewater Arroyo Shale Tongue	90
Dakota	Paguate Sandstone Tongue	25–30
Mancos	Clay Mesa Shale Tongue	50
Dakota	Cubero Sandstone Tongue	20
Dakota	Oak Canyon	70
Morrison	Jackpile Sandstone	0–220
	Brushy Basin	250–350
	Westwater Canyon	0–50
	Recapture	50–100
Bluff		275
Summerville		120
Todilto		75
Entrada		10

LEGEND

- Sandstone
- Shale and Mudstone
- Limestone
- Anhydrite
- Carbonaceous material

FIGURE 2–8
Generalized Stratigraphic Column of the Jackpile Mine Area

0400072

Structure

The geologic structure at the Jackpile-Paguate uranium mine is relatively simple. Sedimentary rocks dip uniformly about 2 degrees to the northwest into the San Juan Basin. One fault (a minor northwest-trending, normal fault) and two low-amplitude folds are present at the southwestern end of the Jackpile pit (Schlee and Moench 1963). Joints are present in all rocks in the area. Vertical joint sets in the Gavilan Mesa highwall are oriented N. 25 degrees E. and N. 35 degrees W. (Seegmiller 1979a). Vertical joint sets in the North and South Paguate pit areas are oriented N. 25 degrees E. and N. 72 degrees W. (Seegmiller 1979b). Joint spacing ranges from 5 to 15 feet in sandstones and less in shales.

Nature of the Ore Deposit

The Jackpile deposit mined in the Jackpile pit was an elongate, tabular ore body in the Jackpile Sandstone Member, approximately 1.5 miles long and 0.5 miles wide. Individual ore layers rarely exceeded 15 feet in thickness, but stacked layers totaled up to 50 feet (Moench 1963). The dominant ore minerals were coffinite, uraninite and numerous oxidized uranium minerals (Moench 1963).

The deposit mined in the North and South Paguate pits had a known length of over two miles and an average width of several hundred feet. The northern part of the deposit was in the upper one-third of the Jackpile Sandstone Member, while in the southern area, the lower two-thirds of the Jackpile Sandstone Member hosted the deposit. Both the Jackpile and Paguate deposits were formed as uranium minerals precipitated from ground water in the presence of carbonaceous material (Moench and Schlee 1967).

MINERAL RESOURCES

Under Federal regulations, details regarding Indian mineral leases (i.e., production data and royalty information) are confidential. The information contained in this section is presented in general terms to protect its confidentiality. Only the information necessary to provide the reader with an understanding of the importance of this issue is presented.

Remaining Uranium Deposits and Protore Stockpiles

Approximately 23 million tons of uranium resources remain at the minesite as stockpiled protore and unmined deposits. Protore is material that was stockpiled throughout the mining operation because it contains elevated but sub-economic uranium concentrations. (For discussion purposes in this EIS, the term "protore" also refers to the remaining Anaconda "ore" stockpiles. These ore stockpiles have been grouped with the protore stockpiles for discussion because they would be treated in the same manner during reclamation).

Approximately 21 million tons of protore, containing .02 to .059 percent uranium (U_3O_8), exist at the minesite. This material is located on the surface in 23 stockpiles dispersed throughout the mine, as shown in Visual A. The protore was generally segregated according to grade, but some variability in grade exists within each stockpile.

Approximately two million tons of unmined deposits containing .094 to .30 percent U_3O_8 remain at the site. These resources are located in 11 deposits, 3 of which contain 90 percent of the resources. These three deposits are the P15/17, the NJ-45, and the P-13 (Visual A).

The P15/17 deposit is located immediately south of the P-10 mine, and was scheduled to be mined by underground methods until depressed uranium market conditions made this mining uneconomical. Approximately 60 percent of the minesite's unmined resources are contained in this deposit. The deposit remains undeveloped.

The NJ-45 deposit is located under Gavilan Mesa, adjacent to the Jackpile Pit. Anaconda constructed three adits and drove drifts to this deposit in 1981, but mined only a small portion of the resource.

The P-13 deposit is located east of the P-10 mine, adjacent to the South Paguate Pit. Anaconda constructed two adits and drove two drifts to this deposit in 1981, but did not mine the resource. Operations at both the NJ-45 and P-13 mines were suspended when Anaconda closed the overall project.

NON-RADIOLOGICAL MINESITE HAZARDS

Non-radiological hazards at the Jackpile-Paguate minesite include: 1) unstable highwalls, 2) unstable waste dumps, 3) possible subsidence, and 4) underground openings. All of these present a potential physical hazard to humans and livestock as well as a long-term environmental hazard.

Slope Stability

Mine highwalls and waste dumps frequently present safety problems that require carefully designed mitigation procedures. These hazards include:

1. Rockfalls - Toppling and falling of loose sandstone blocks that occurs on all highwalls at the minesite.

2. Rotational failures - These landslides occur in loose rock or soil, and break along concave-upward curved surfaces.

3. Translational failures - These occur in hard rocks, and break along pre-existing zones of weakness i.e., faults or joints. (Note: slope failures may exhibit characteristics of several of these above types.)

Conclusions about slope stability are based on the slope safety factor, which is the ratio between the forces available to resist slope failure and the forces tending to cause this failure. This safety factor is calculated from the friction angle, cohesion and specific (unit) weight of the rock or waste material being analyzed. These properties are determined from field measurements and laboratory tests. The safety factor itself can be calculated using several different methods. Anaconda used the Hoek method while the DOI used the Morgenstern - Price method. The concensus is that these two methods give comparable results.

Generally, a safety factor less than 1.0 indicates instability, while a safety factor greater than 1.0 indicates relative stabilty under the conditions assumed. However, because of the many assumptions used in this EIS and because a margin of safety is needed, the following scale for safety factor and stability is used:

Safety Factor $\leq$ 1.0	Unstable
Safety Factor > 1.0 but < 1.2	Marginally stable
Safety Factor $\geq$ 1.2 but < 1.5	Probably stable
Safety Factor $\geq$ 1.5	Stable

In calculating the safety factor, the effect of cohesion of earth materials is taken into account, because cohesion inhibits slope failure. Cohesion of materials decreases over time, and may approach zeros, but past experience indicates that assuming zero cohesion underestimates slope stabilities. However, assuming maximum (laboratory-determined) cohesion leads to over-estimation of stability. Therefore, the following analyses assume cohesion of 50 percent of laboratory values.

Highwall Stability

The three major areas with highwalls at the mine are Jackpile pit (Gavilan Mesa), North Paguate pit and South Paguate pit (Visual A). Safety factors for them are given in Table 2-8. All three highwall areas are composed of Dakota Sandstone and Mancos Shale. Highwall slopes in the shale units are about 40 degrees, while the sandstone slopes are nearly vertical.

TABLE 2-8

SAFETY FACTORS FOR HIGHWALLS

Pit Highwall	Safety Factors	
	Anaconda[a]	DOI[b]
Jackpile (Gavilan Mesa)	1.40	1.15-1.26
North Paguate	1.63	1.58-1.63
South Paguate	1.87	1.29-3.05

Source: [a]Seegmiller 1981.
[b]Smith 1983.

The Gavilan Mesa highwall is the tallest at the mine; its crest measures just over 500 feet (Figure 2-9). Its slope angle ranges up to 74 degrees, with an overall angle of 49 degrees (Seegmiller 1981a.) This highwall has up to six benches 25 to 50 feet wide. Several tension cracks occur on the first bench below the crest of the highwall. Numerous overhanging and loose sandstone blocks are also present and are most common where several joints intersect with bedding planes and the cliff face. Under present conditions, sections of the Gavilan Mesa highwall are only marginally stable for the long-term. The most likely slope failure would be a rotational one. This type failure would involve most benches and result in a large volume of material sliding to the toe of the highwall.

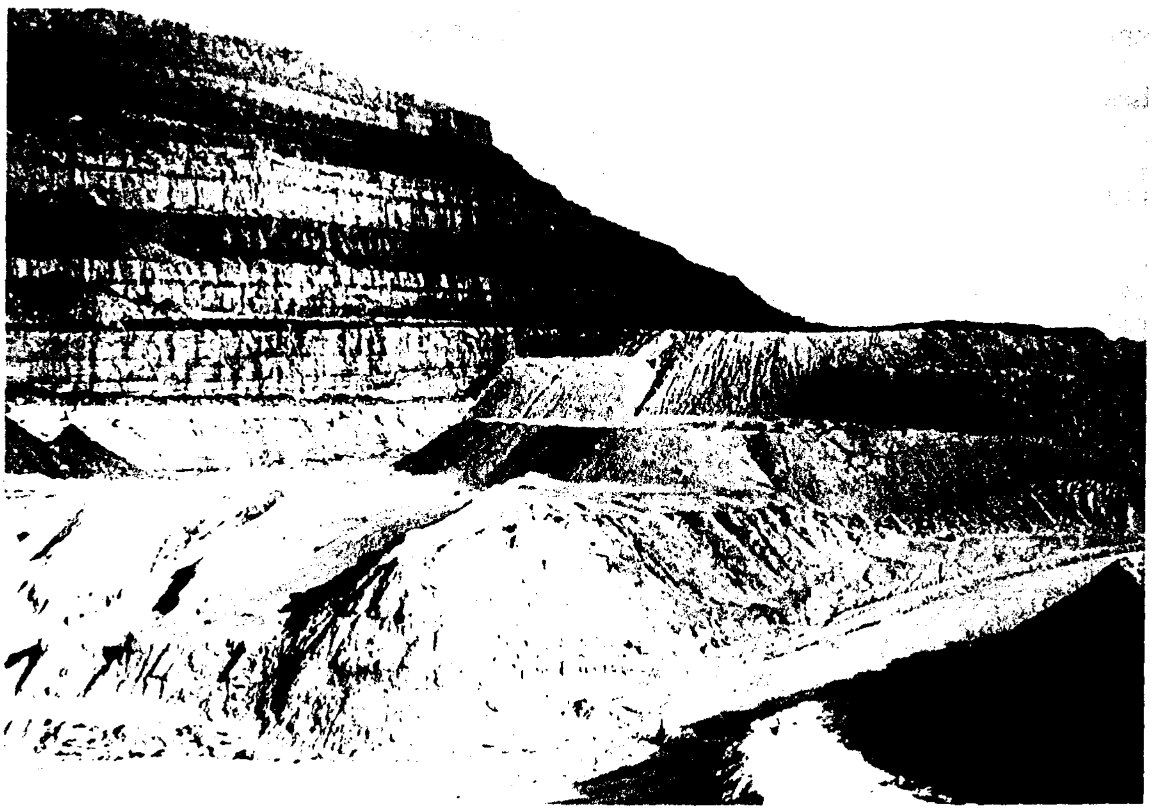


FIGURE 2-9 JACKPILE (GAVILAN MESA) PIT HIGHWALL WITH BUTTRESS MATERIAL AT BASE

Toward the end of mining operations, Anaconda placed waste material against the base of Gavilan Mesa to help stabilize the highwall. The rim of the highwall is not fenced.

The North Paguate pit highwall has a maximum height of 200 feet and a slope angle that ranges up to 70 degrees; the maximum overall slope angle is 55 degrees (Seegmiller 1981a). This highwall has up to three benches 15 to 20 feet wide. It is considered stable for the long term. That portion of North Paguate pit highwall close to the Village of Paguate is fenced with six-foot chain link.

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The South Paguate pit highwall reaches a maximum height of about 300 feet. The slope angle ranges up to 80 degrees, with the maximum overall slope angle being 50 degrees (Seegmiller 1981a). This highwall has up to five benches 5 to 25 feet wide. In places, the South Paguate pit highwall is capped by up to 150 feet of alluvium. Under present conditions, the highwall is probably stable over the the long-term. If a slope failure were to occur, it would most likely be a steep-angled rotational one involving the entire highwall. The rim of the highwall is not fenced.

Waste Dump Stability

Potential hazards resulting from waste dump instability at the mine include: rotational failures, base translational failures, foundation spreading and piping. These waste dump failures could expose radiological material and thus present a health and environmental hazard. The material properties of eight waste dumps have been analyzed to assess existing stabilities (safety factors), including rotational failures through the dump toes, and translational failures along the dump bases (Seegmiller 1980b). The eight waste dumps analyzed are those where the most severe stability problems could be expected. Safety factors for the eight dumps under rotational and base translational failure are given in Table 2-9. These safety factors are applicable only under short-term conditions (with cohesion present) and are not applicable to long-term stability (with diminishing cohesion). Saturation of a dump in the climate at the minesite is not considered likely, so conclusions about rotational failure assume dry conditions.

TABLE 2-9

SAFETY FACTORS FOR WASTE DUMPS

Dump	Rotational Failure (dry conditions)[a]	Base Translational Failure	
		Static[a]	Dynamic[b]
FD-2	1.5	.84	<1.1
I	2.1	29.00	>1.1
South Dump	1.6	29.00	<1.1
T	2.2	29.00	<1.1
U	3.0	29.00	<1.1
V	1.4	29.00	<1.1
Y	4.0	29.00	>1.1
Y_2	3.5	29.00	<1.1

Source: Seegmiller 1980b.

Notes: [a]Minimum safety factor of 1.5 or greater.
[b]Minimum safety factor of 1.1 or greater

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The Seegmiller analysis (1980b) indicates that, under conditions assumed, all dumps are at least "probably stable" with regard to rotational failure, and that all dumps except FD-2 are stable in regard to base translational failure under static conditions. The analysis also indicates that the two most critical dumps, in terms of stability, are FD-2 and V dumps.

FD-2 is a 270-foot-high dump composed of shale and Tres Hermanos Sandstone (Figure 2-10). It lies on a steep slope on the south side of Gavilan Mesa. Tension cracks are present near the crest. Although Seegmiller calculated a safety factor of 1.5 (rotational failure under dry conditions), this dump appears to be just marginally stable. If one assumes no cohesion, FD-2 is unstable with regard to rotational failure. If the dump were to fail, a slump would probably displace the upper one-third to one-half of the dump, with the displaced material sliding to the base of the mesa.

V dump, approximately 215 feet high and composed mostly of Jackpile Sandstone, is located near the Rio Moquino (Figure 2-11). The southwest side of this dump shows slide scars near the dump toe. Seegmiller's analysis shows this dump to be stable under short-term conditions (cohesion present), but under zero cohesion conditions, this dump has a safety factor against rotational failure of 1.0, i.e., it is unstable.

Slopes sometimes fail when the materials underlying them cannot hold up the weight of overlying materials. This is called failure by foundation spreading. This has not been a problem at the Jackpile-Paguate mine in the past, and is not expected to be a problem except at FD-2 dump, where fissures in materials underlying the base of the dump suggest foundation spreading.

Piping is a process in which surface water flows downward through unconsolidated material, eroding the material to form a hollow tube or pipe. Piping on waste dump tops is common, especially where water ponds against erosion control berms. Piping causes geologic hazards at the minesite in two ways:

1. Areas around large, deep pipes are unstable, leading to a greater liklihood of human or livestock accidents.

2. Piping at dump crests has initiated large gullies at D,I,T,V and South dumps. These gullies are sources of rockfalls, small earth slides and high-velocity concentrated runoff.

Subsidence

Information on existing ground subsidence above the underground mine workings is presented in Table 2-10. As of June, 1986, a maximum of 4.16 inches of subsidence has occurred at one station over the 1500 area of the P-10/7 mine (Anaconda 1984).

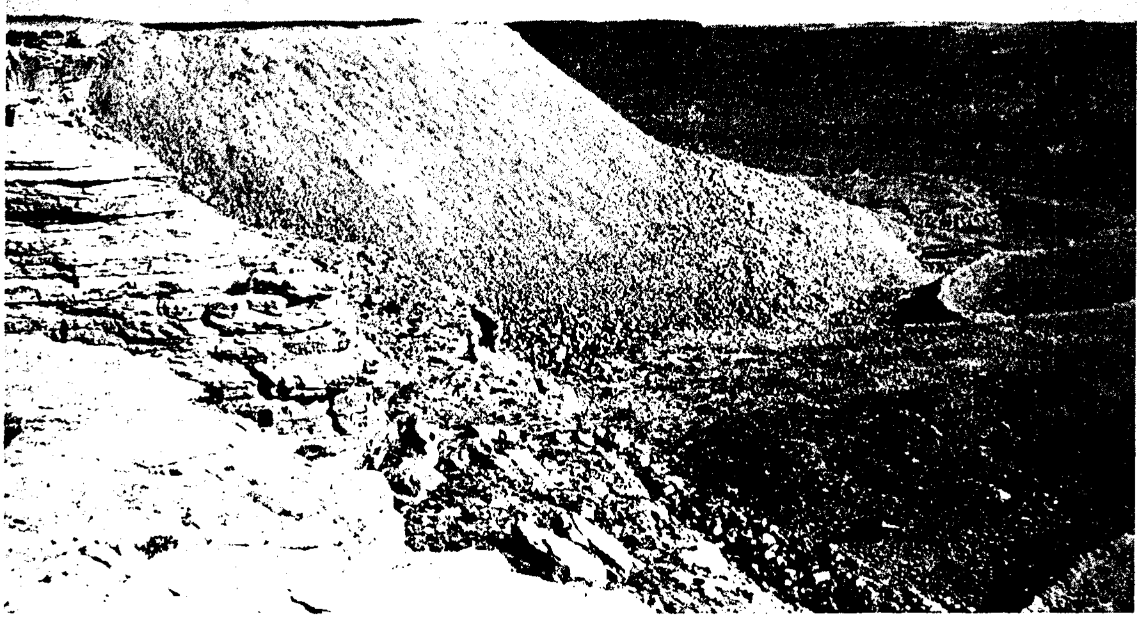

FIGURE 2-10 FD-2 DUMP ON EAST SIDE OF GAVILAN MESA

FIGURE 2-11 V DUMP SHOWING ACTIVE EROSION

TABLE 2-10

SUBSIDENCE DATA ON UNDERGROUND MINES - JACKPILE-PAGUATE MINESITE

Mine	Depth (Feet)	Mining Height (Feet)	Overlying Strata[a]	Ground Surface	Subsidence Monitoring Grid	Subsidence
Alpine	70	9 to 12	JSS, DS	Undisturbed	None	None observed
H-1	140 to 200	8 to 13	JSS, DS, MS	Undisturbed	None	None observed
NJ-45	35 to 320	10	JSS, DS, MS	Disturbed - pit and highwall	None	None observed
P-9-2	140 to 160	9 to 20	JSS, DS, MS	Undisturbed	None	None observed
P-10/7 (and P-13)	200 to 600	9 to 45	JSS, DS, MS COLL	Mostly disturbed	81 stations at Hwy 279 (estab. 1976)	Range: -0.02 to -4.16 inches
PW 2/3	40 to 140	9 to 15	JSS, DS, MS	Disturbed - pit	8 stations (estab. 1978)	Range: -0.04 to -0.68 inches
Woodrow	Up to 200	-- [b]	Backfill	Disturbed	None	None observed

Sources: Seegmiller 1981d, Anaconda Minerals Company 1986.

Notes: [a] JSS=Jackpile Sandstone; DS = Dakota Sandstone; MS = Mancos Shale; COLL = Colluvium.
[b] -- = Unknown.

Seegmiller (1981b, c, d) studied several possible problem areas at the mine. These are the A and B stopes of the Alpine mine, the 1400B stope of the P-10/7 mine and the A and B stopes of the PW 2/3 mine. Seegmiller's estimates of subsidence at these sites are shown in Table 2-11. The data indicate that all areas, except for the area above the P-10 mine decline, are in a "low risk" category with regard to subsidence. The P-10 decline could be subject to subsidence of significant magnitude and rate. This is because, from the surface to 680 feet down the decline, the ratio of overburden to mining height is less than 10:1. As a general rule, mine voids with values of this ratio of less than 10:1 may be unstable without support.

TABLE 2-11

PREDICTED MAGNITUDE AND RATE OF SUBSIDENCE OVER POSSIBLE PROBLEM STOPES AT UNDERGROUND MINES

Mine Area	Probable Subsidence	Probable Rate
Alpine Mine, A stope	6"	Very Slow
Alpine Mine, B stope	4"	Very Slow
PW 2/3, A stope	6"	Very Slow
PW 2/3, B stope	12"	Very Slow
P-10/7, 1400B stope	1"	Zero to Very Slow

Source: Seegmiller 1981b,c,d.

Underground Openings

The Alpine mine was accessed by two adits that have been sealed by backfilling with 5 to 10 feet of waste material. No bulkheads were placed in either adit. The area surrounding the adits has been backfilled to above the portals.

The H-1 mine was accessed by two adits, one of which has been backfilled 20 feet inward from the portal. The other adit is sealed by waste material only at the portal. The three ventilation shafts have been backfilled from bottom to surface and are covered by a 5-foot-high surface mound.

The NJ-45 mine was accessed by four adits, three of which accessed the workings, while only the portal of the fourth adit was constructed. Ventilation was supplied by two 42-inch ventilation shafts. All mine workings are barricaded but not backfilled.

The P-9-2 mine was accessed by five adits and ventilated by eight 42-inch ventilation shafts. Open-pit operations progressed through the mine workings and seven of the ventilation shafts. The remaining ventilation shaft is still open. The mined areas have been backfilled above the level of the remaining underground workings.

The P-10/7 mine was accessed by one decline and an emergency escapeway that leads into the South Paguate pit. It was ventilated by seventeen 42-inch ventilation shafts. All mine entries are barricaded but not backfilled.

The P-13 mine was accessed by two adits that are still open. However, this mine has flooded naturally.

The PW 2/3 mine was accessed by four adits, the portals of which have been backfilled. Subsequent backfilling has covered three of the portals.

The Woodrow mine was accessed by a 225-foot deep shaft. The shaft has since been backfilled to the surface.

RADIATION

Introduction

This section describes the existing radiological environment in and around the Jackpile-Paguate uranium mine. A primer on radiology, including the terminology used in this EIS, is given in Appendix C.

Standards

No specific standards exist for the release of radiation and radioactive materials from uranium mining operations, nor do specific standards exist for post-reclamation radiation levels. Standards have been developed by the Federal government for active uranium mills, inactive uranium mills, public drinking water systems and point-source discharges of water (Table 2-12). In addition, the U.S. Federal Radiation Council, (since merged into the U.S. EPA) published general radiation protection guidelines on May 13, 1960. These guidelines provided that 1) there should not be any man-made radiation exposure without the expectation of benefit resulting from such exposure, and 2) that every effort should be made to encourage the maintenance of radiation doses as far below the guidelines as practicable (what is now known as the ALARA principle). These standards and guidelines provide a useful comparison by showing the levels of radiation and radioactive materials that are considered acceptable for other situations.

Sources of Radiation of the Minesite

Uranium and all members of its decay chain are present everywhere in low concentrations in air, soil and water. However, special geologic and hydrologic conditions at the minesite have allowed uranium from the ground water to be deposited in much higher concentrations than background levels.

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TABLE 2-12

FEDERAL RADIATION STANDARDS

Source of Standard	Subject	Standard[a]	
		Item	Limit
Nuclear Regulatory Commission (10 CFR 20.105 and 20.106)	Permissible levels of radiation in unrestricted areas[b]	Annual whole body dose to an individual	0.5 rem (equivalent to 57 microroentgens per hour)
		Radon-222	3 pCi/l (individual)[c] or 1 pCi/l (population)
Environmental Protection Agency (40 CFR 141.15)	Maximum levels for radium-226, radium-228 and gross alpha particle activity in community water systems	Combined radium-226 and radium-228	5 pCi/l
		Gross alpha (including radium-226 but excluding radon and uranium)	15 pCi/l
(40 CFR 192)	Health and environmental protection standards for uranium mill tailings	Radon-222 release from uranium by-product materials	20 $pCi/m^2 \cdot s$[b]
		Radon-222 concentrations at the boundary of a disposal site	0.5 pCi/l
		Radium-226 in land averaged over 100 square meters	5 pCi/g (over the first 15 centimeters of soil below the surface)[c]
			15 pCi/g (averaged over 15-centimeter-thick layers of soil more than 15 centimeters below the surface)
		Radon daughter and gamma levels inside buildings at abandoned mill sites	.03 WL and 20 $\mu R/h$[c]
(40 CFR 440.52)	Concentration of pollutants discharged in drainage from uranium mines, either open-pit or underground (<u>in situ</u> leach mines excluded)	Radium-226 (dissolved)	10 pCi/l (daily maximum) 3 pCi/l (30-day average)
		Radium-226 (total)	30 pCi/l (daily maximum) 10 pCi/l (30-day average)
		Uranium	4 mg/l (daily maximum)[c] 2 mg/l (30-day average)

Notes: [a] Air standards are above background; water standards include background.
[b] 10 CFR 40.13 specifically excludes "... unrefined and unprocessed ore..." (i.e., mines and mining).
[c] Units of measurement: pCi/l = picocuries per liter; $pCi/m^2 \cdot s$ = picocuries per square meter per second; pCi/g = picocuries per gram; WL = working level; $\mu R/h$ = microroentgens per hour; mg/l = milligrams per liter.

The decay of some of the uranium in the ore at the minesite has led to the presence of all members of uranium decay series in the deposits. Because this decay has been occurring over a very long period of time, it has reached a state of "secular equilibrium," i.e., the radioactivity of each member of the decay chain is the same as that of the uranium-238, the parent.

During mining operations, the ore with the highest concentration of uranium was removed, thereby decreasing somewhat the total amount of radiation produced at the site. However, the mining operation increased the rate at which the radiation was released into the immediate vicinity of the site by bringing the radioactive ore to the surface (i.e., by removing the shielding of the overburden) and by altering the ore's chemical and physical properties. The sources of radiation at the site (other than normal background) are protore, ore-associated waste and the unmined portions of the uranium ore deposit. The radiological characteristics of surface materials at the minesite are shown on Table 2-13.

The protore at the minesite consists of approximately 15.5 million tons of rock containing 0.02 to 0.059 percent uranium oxide (U_3O_8). The protore is located in 23 stockpiles inside and outside of the open pits. [In mining, the concentration of all uranium isotopes (U-234, U-235, U-238) present in a certain amount of rock is expressed as if the isotopes existed as an equivalent amount of uranium oxide (U_3O_8). This U_3O_8 equivalent is expressed as a percentage by weight.]

The ore-associated waste consists of an unknown quantity of rock containing 0.002 to 0.02 percent U_3O_8. Records were not required on the exact uranium content, nor on the deposition sites of the ore-associated waste. This waste was mixed indiscriminately with the overburden and placed in the 32 waste dumps on the site, or was used as backfill material. It is estimated that 50 million tons of ore-associated waste remain at the site, but this number might be in error by a substantial amount.

The site also contains about 2 million tons of unmined uranium resources containing 0.094 to 0.3 percent U_3O_8 and an unknown amount of resources below 0.094 percent. These resources have not been disturbed by mining operations and contribute little to the amount of radiation released from the site because they are shielded by the overburden.

The minesite has an average of 70 picocuries per gram of radium-226 and uranium-238. These values are about 47 times higher than the average background levels and about 14 times higher than the U.S. Environmental Protection Agency's mill tailings standard (40 CFR 192).

TABLE 2-13

RADIOLOGICAL CHARACTERISTICS OF SURFACE MATERIALS
AT THE JACKPILE-PAGUATE MINE

Site Designation[a]	Area (Acres)	U-Natural Analysis µg/gm	U-Natural Activity pCi/gm	Gamma µr/hr Average
Dump A	23	4.50	3.20	11
Dump B	71	2.70	1.90	10
Dump C	21	2.70	1.83	5
Dump D	14	4.05	2.74	5
Dump E	12	1.50	1.01	5
Dump F	73	4.03	2.73	5
Dump G	49	5.82	3.94	5
Dump H	7	146.80	99.38	29
Dump I	57	10.00	7.00	5
Dump J	15	10.66	7.22	75
Dump K	22	20.30	13.74	7
Dump L	58	5.50	3.72	5
Dump N	48	42.00	30.00	9
Dump N2	16	200.00	150.00	30
Dump O, P, P1, P2	35	3.12	2.11	12
Dump Q	52	160.00	120.00	68
Dump R	14	11.00	8.00	24
Dump S	96	2.79	1.89	10
Dump T	32	3.90	2.80	9
Dump U	61	34.29	23.21	52
Dump V	51	13.94	9.44	34
Dump W	7	2.50	1.80	10
Dump X	9	18.00	13.00	5
Dump Y	30	33.42	22.62	13
Dump Y2	15	4.20	3.00	5
South Dump	175	4.90	3.50	8
FD-1	168	2.70	1.90	10
FD-2	25	45.00	32.00	3
FD-3	10	14.00	10.00	28
17BC (SP-17BC)	15	220.00	150.00	581
6A (SP-6-A)	17	200.00	140.00	388
6B (SP-6-B)	9	130.00	93.00	383
J1 (J-1)	9	94.00	67.00	155
J2 (J-2)	8	490.00	350.00	606
17D (MILLED)	3	520.00	370.00	198
1B (1-B)	9	140.00	100.00	237
2C (SP-2-C)	12	110.00	79.00	422
10 (10 DIKE)	3	390.00	280.00	506
2D (SP-2-D)	6	180.00	130.00	419
1C (SP-1-C)	5	61.00	44.00	227
1A (SP-1-A)	20	31.00	22.00	161
2E (2-E)	3	220.00	160.00	451
SP-1	9	130.00	95.00	354
PLG	3	5.00	3.60	210
4-1	8	77.00	55.00	266
SP-2 (MILLED)	12	180.00	130.00	300
SP-2B (MILLED)	2	610.00	440.00	164
TS-1	21	4.90	3.50	8
TS-2A	5	4.90	3.50	18
TS-2B	6	2.90	2.10	6
TS-3	19	3.60	2.60	11
Topsoil Borrow Site	43	4.10	2.90	17
Jackpile Pit				
. North	159	28.00	20.00	128
. Central	158	180.00	130.00	107
. South	158	760.00	540.00	165
N. Paguate Pit				
. West	47	47.94	32.45	27
. Central	47	53.00	38.00	113
. East	46	85.00	61.00	79
S. Paguate Pit				
. West	134	4.30	3.10	20
. Central	133	17.00	13.00	29
. East	133	24.00	17.00	72
Housing Area	19	8.00	6.00	22
Shop Area	17	24.00	17.00	36
Old Shop Area	4	37.00	27.00	44
P-10 Adit Area	3	120.00	86.00	192
Pit Offices	2	31.00	22.00	44
Park Lot at SP-1	7	56.00	40.00	78
Park Lot at SP-2	12	32.00	23.00	102
Rail Spur	7	180.00	130.00	104
(on lease area) Roads	88	35.00	23.70	75

Source: Anaconda Minerals Co. 1982.

Note: [a]Original designations supplied by Anaconda; designations in parentheses correspond to Visual A in this EIS.

The protore piles contain concentrations up to 165 picocuries per gram : both radium-226 and uranium-238. Small localized pockets may exceed) picocuries per gram for these elements.

Radiation Exposure Pathways and Existing Levels of Radiation

The principal potential pathways for human exposure to radiation from e minesite are as follows:

1. Direct Gamma Radiation--Direct exposure to radiation emitted by e radioactive material on the surface of the ground at the site. posure is to the whole body, but applies only to people at the minesite self. (Direct exposure to beta radiation is also a potential exposure ιthway, but the health impacts from direct gamma exposure far exceed ιose of beta radiation. All measures taken to reduce direct external ιmma radiation would also reduce external beta radiation. Therefore, ιrect external beta radiation is not analyzed any further in this ocument.)

2. Ambient Radon--Inhalation of radon-222 and its radioactive decay roducts (progeny) from the continuous decay of radium-226 in the protore nd ore-associated waste; exposure is primarily to a portion of the lungs rom radon-222 progeny.

3. Particulates--Inhalation of windblown particles containing adioactive elements; exposure is to the lungs from the progeny of the ıranium-238 decay chain.

4. Water--Consumption of surface or ground waters containing adioactive elements; exposure is primarily to the bone and stomach from ıll progeny of the uranium-238 decay chain.

5. Ingestion--Consumption of meat and vegetables contaminated with radioactive elements.

Any of the exposure pathways mentioned above would be created by radioactive material that has been removed from the site by water erosion, spillage along ore haul routes or purposely taken from the site.

Direct Gamma Radiation

Gamma rays are continuously emitted from the radioactive decay of many elements contained at the minesite in protore and ore-associated waste. The principal gamma emitters are decay products of uranium-238, mainly bismuth-214 and lead-214.

Gamma rays cannot penetrate long distances through dense material. For example, one foot of compacted earth shields about 90 percent of the gamma radiation (Ford, Bacon & Davis Utah, Inc. 1977). Therefore, only the gamma rays that are produced at or very near the ground surface enter the atmosphere. In the atmosphere, gamma rays may travel up to 500 yards before they are absorbed by the air; therefore, people must be within 500 yards of the gamma-emitting source to be exposed. The closer a person is to the source, the greater the dose received.

Exposure to gamma rays can be very hazardous because gamma can penetrate the human body and expose all organs. The potential damage to these organs from ionizing radiation is discussed in Appendix C. The Nuclear Regulatory Commission (10 CFR 20.105) limits gamma exposure in unrestricted areas to no more than 0.5 rem per year [0.5 rem/year = 57 microroentgens per hour (uR/h)] over background. As previously mentioned, this standard does not apply to uranium mines. However, it does put the following discussion of gamma levels in perspective.

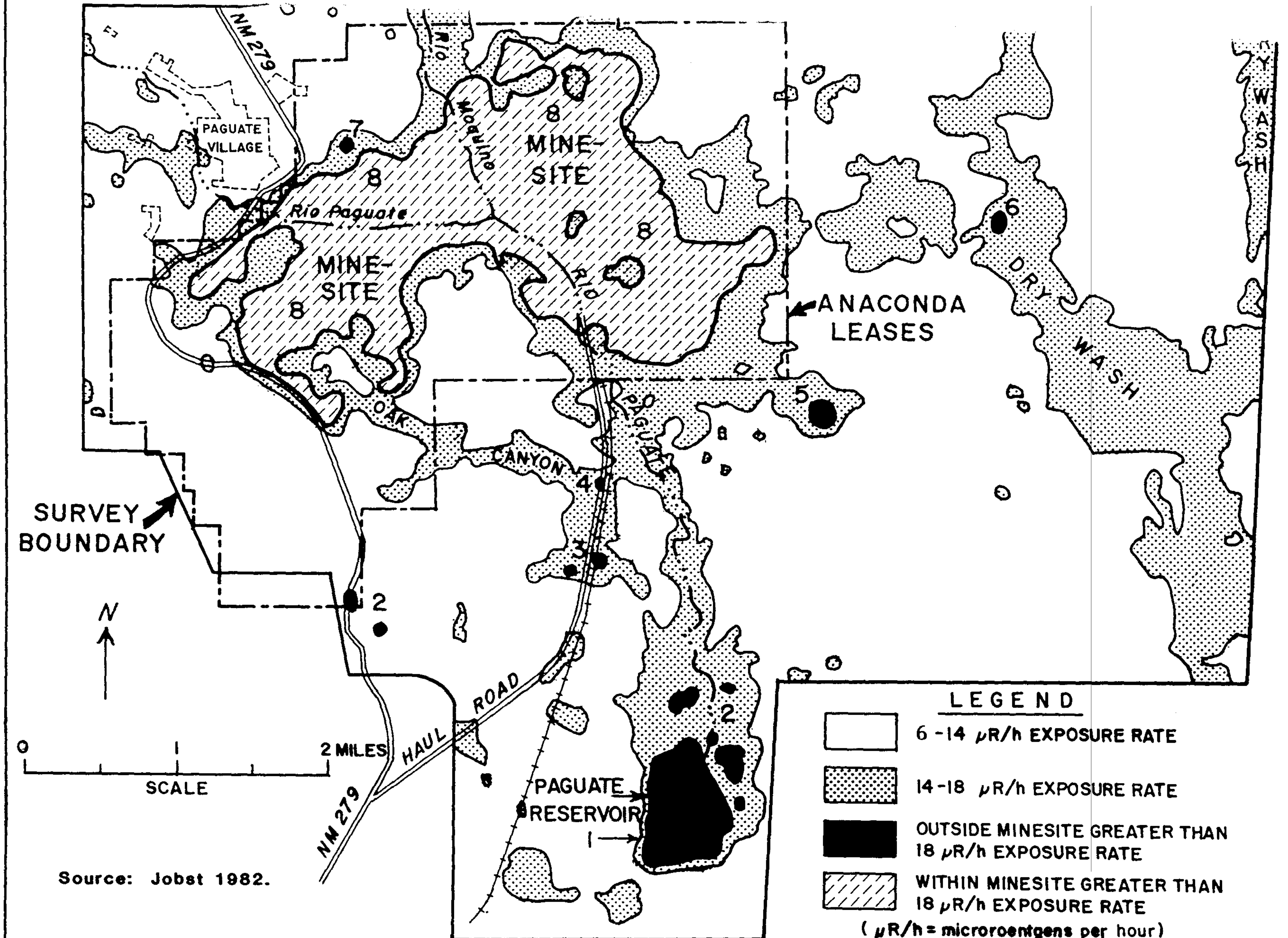
An aerial survey was conducted at the minesite and the surrounding areas to determine the levels of gamma radiation being emitted from the site and vicinity, to discover if winds had spread radioactive material offsite, and to locate any spills. This aerial survey was used to determine background gamma radiation levels to be used as a basis for reclamation evaluation. The survey was performed in July and August, 1981, by the Energy Measurements Group of EG&G (Jobst 1982). Corrections were made in the data for the altitude of the helicopter, terrestrial radiation, and cosmic radiation, to obtain an exposure rate 3 feet above the ground due to gamma sources in the soil. The results of the survey are shown on Maps 2-1 and 2-2.

The background gamma exposure rate is 13 uR/h; most of the area outside of the minesite, including the Village of Paguate, is at background levels.

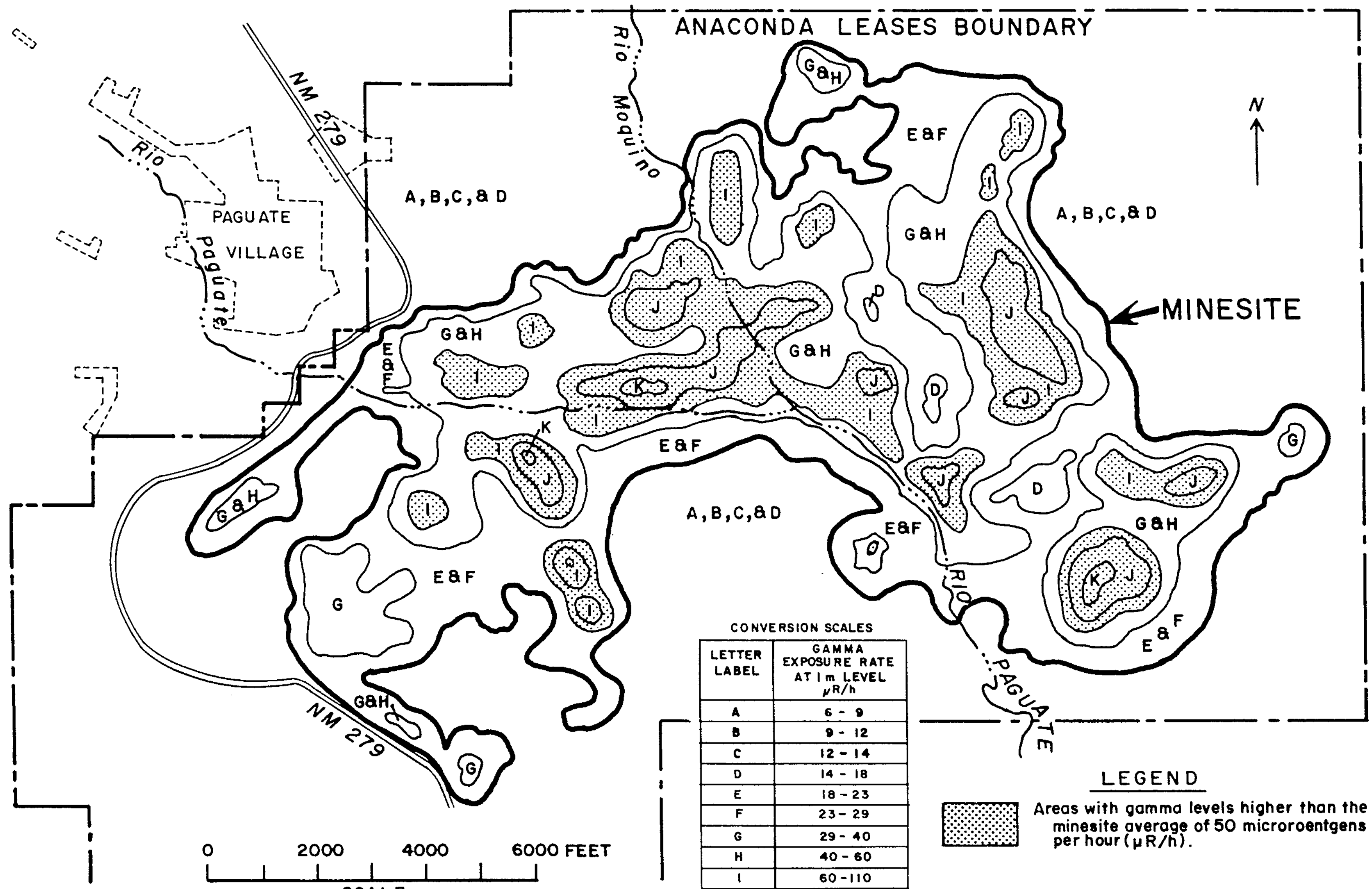
Those areas that have exposure rates above background values are shown on Maps 2-1 and 2-2. Slightly elevated (14 to 18 uR/h) levels were measured in all major drainages above and below the minesite. A followup ground survey showed the high exposure rates in these areas are primarily due to spillage of ore and to natural outcrops of uranium- bearing rock. Conditions at areas 1, 3, 4, 7 and 8 on Map 2-1 resulted from the mining operations. More detail for each of these high exposure areas is provided in Table 2-14.

The exposure rates within the minesite are shown on Map 2-2. The maximum exposure rate of 480 uR/h is approximately 37 times the background level of 13 uR/h, while the average exposure rate of 50 uR/h is approximately 4 times background. The protore piles have the highest exposure rates. Areas that have been covered with soil, such as dumps C through G, have exposure rates at or below 18 uR/h.

Paguate (Quirk) Reservoir was studied to determine the concentration of radioactive elements in the sediment. A surface gamma survey consisting of 1,500 data points was conducted in and around the reservoir (Eberline Instrument Corp. 1981). Also conducted was a subsurface gamma survey consisting of 47 drillholes (a maximum of 30 feet deep) and 7



MAP 2-1 Aerial Gamma Survey of the Minesite and Surrounding Area



CONVERSION SCALES

LETTER LABEL	GAMMA EXPOSURE RATE AT 1 m LEVEL μR/h
A	6 - 9
B	9 - 12
C	12 - 14
D	14 - 18
E	18 - 23
F	23 - 29
G	29 - 40
H	40 - 60
I	60 - 110
J	110 - 200
K	200 - 480

Source: Jobst 1982.

MAP 2-2 Aerial Gamma Survey of the Minesite

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TABLE 2-14

EXPLANATION OF HIGH GAMMA EXPOSURE AREAS

Area Number[a]	Exposure Rate (μR/h)[b]	Source of Elevated Exposure Rates
1	18-29	Sediments in Paguate (Quirk) Reservoir. Partially the result of erosion from the minesite and partially the result of erosion from undisturbed areas.
2	18-23	Natural outcrop of uranium-bearing rock
3	18-29	Ore spillage along rail spur
4	18-29	Ore spillage along rail spur
5	18-23	Natural outcrop of uranium-bearing rock
6	18-23	Natural exposure of uranium-bearing sediments
7	18-23	Location of Anaconda's hydraulic mining test
8	18-480	Jackpile-Paguate minesite

Source: Jobst 1982.

Notes: [a]Area numbers are the locations shown on Map 2-1.
[b]μR/h = microroentgens per hour.

trenches (a maximum of 5 feet deep) in the reservoir. The gamma exposure rates and the percentage of the reservoir area exhibiting these exposure rates are given in Table 2-15.

Slightly more than 31 percent of the reservoir exhibits exposure rates above background values, with the maximum rate measured being about 2.5 times background. The airborne gamma survey (previously discussed) showed the background exposure rate for the stream channels in the area to be 14 to 18 μR/h.

Six villages on the Laguna Reservation (including Paguate and Laguna) and three villages near the reservation were surveyed for gamma radiation by the U.S. Environmental Protection Agency (EPA) on September 6, 1980 (EPA letter of January 25, 1983). A truck-mounted gamma scanner was driven through each village to locate radiological anomalies.

Twenty-five such anomalies were found. A follow-up survey of them was performed the week of February 9, 1981, using pressurized ion chambers or scintillometers. Often, the source of the anomaly was found to be a

TABLE 2-15

GAMMA EXPOSURE RATES AT PAGUATE PRESERVOIR
(microroentgens per hour)

Exposure Rate	Percentage of Reservoir
Less than 10	22
11-20	47
21-30	27
Greater than 30[a]	4

Source: Eberline Instrument Corporation 1981.
Note: [a] The maximum rate measured was 47 microroentgens per hour.

single rock, which was removed. Only three locations were found to have gamma exposure rates above 16 μR/h. These three had rates of 32, 37 and 600 μR/h. The source of each was found to be rock or soil located outside of buildings, and all sources were removed. Therefore, no anomalies above 16 μR/h (slightly above background) remain.

Data are not available on the radiological levels in the buildings on the minesite, but levels of gamma radiation are expected to be high due to spillage of ore in and around the buildings.

Ambient Radon

The exposure of the public to radon (Rn-222) and its decay products represents one of the greatest potential health risks from the mine. Rn-222 is produced continuously by the radioactive decay of the radium (Ra-226) present in the protore and ore-associated waste. Rn-222 is an inert gas that diffuses through the protore and waste into the atmosphere, where it can be dispersed by winds. Rn-222 has a half-life of 3.82 days, so a given amount may travel some distance in the atmosphere before it completely decays.

The mining operations decreased the total amount of Rn-222 that would ultimately be released from the minesite by removing the high-grade ores; however, these same operations have also increased the rate at which Rn-222 is released into the atmosphere by uncovering the ore zone and placing the protore and waste on the surface. Before mining, most of this material was deeply buried, and much of the Rn-222 changed to its solid decay products before it could diffuse through the rock and enter the atmosphere. Because the protore and waste have been placed uncovered on the surface, a higher percentage of the Rn-222 enters the atmosphere before it decays.

The total radon release rate from the minesite is calculated to be 5,588 curies (Ci) per year (Momeni, et al. 1983). Of this amount, 3,915 Ci (70 percent) come from the protore, 1,396 Ci (25 percent) from the ore-associated waste, and 280 Ci (5 percent) from material containing less than 5 picocuries uranium-238 per gram.

Data on ambient radon concentrations measured at four locations at the minesite since February 1979 are summarized in Table 2-16. The average of all concentrations was 2 1/2 times background levels, and the maximum concentration measured was 7 times background. Radon Concentrations typically show considerable variability because they are affected by local atmospheric stability conditions and ground moisture.

During June, 1976, the U.S. Environmental Protection Agency performed ambient radon surveys in the vicinity of the Laguna Reservation (Eadie, et al. 1979). The average radon concentration of locations near or at the minesite and those away from the minesite were 1.13 picocuries per liter (pCi/l) and 0.53 pCi/l respectively (Map 2-3, Tables 2-17 and 2-18).

Radon levels in most of the mine buildings are not expected to be higher than in the ambient atmosphere (1.27 picocuries per liter) because most buildings are not tightly constructed. Radon levels in the tightly constructed buildings such as the employee housing, geology building, and offices are expected to be higher because these buildings have reduced radon leakage.

Radon exhalation (the rate at which radon is released from a given area of ground) was measured at four waste dumps that have been covered with soil. This data is summarized in Table 2-19. The average exhalation rate measured was 2.6 times higher than background. Radon exhalations at six locations on the Laguna Reservation as measured by the EPA (Eadie, et al. 1979) averaged 0.5 picocuries per square meter per second (Table 2-20).

Particulates

Radioactive dust particles containing uranium-238, radium-226 and thorium-230 can pose an inhalation hazard to humans. After being inhaled, these particles may deposit in the respiratory tract and decay, releasing alpha, beta, or gamma radiation (or a combination of these).

Table 2-21 shows the results of an EPA study of airborne radioactive particulate concentrations outside the minesite (Eadie, et al. 1979). Table 2-22 shows the results of Anaconda's own particulate survey for concentrations within the minesite are about ten times higher than those outside the minesite. In all cases, however, the concentrations are far below the recommended Nuclear Regulatory Commission standards (10 CFR 20.106).

TABLE 2-16

RADON-222 CONCENTRATIONS AT MONITORING LOCATIONS
(picocuries per liter)

Monitoring Location	Range	Average
Dump F	0.01 - 3.68	1.35
Mine Vent	0.1 - 3.68	1.47
West Gate	0.06 - 2.17	0.96
Well #4	0.01 - 2.78	1.31
Average	0.01 - 3.68	1.27
North Jackpile Pit[a]		5.3
South Paguate Pit[a]		5.1
Housing Area[a]		3.5
Typical background[b]		0.50
EPA Mill Tailings Standard[c] (40 CFR 192)		0.50 (above background)
NRC Standard[c] (10 CFR 20)		3.0 (above background)

Source: Anaconda Minerals Company 1982c.

Notes: a/Western Radiation Consultants 1982.
b/As listed in Eadie, et al. 1979.
c/Refer to Table 2-12.

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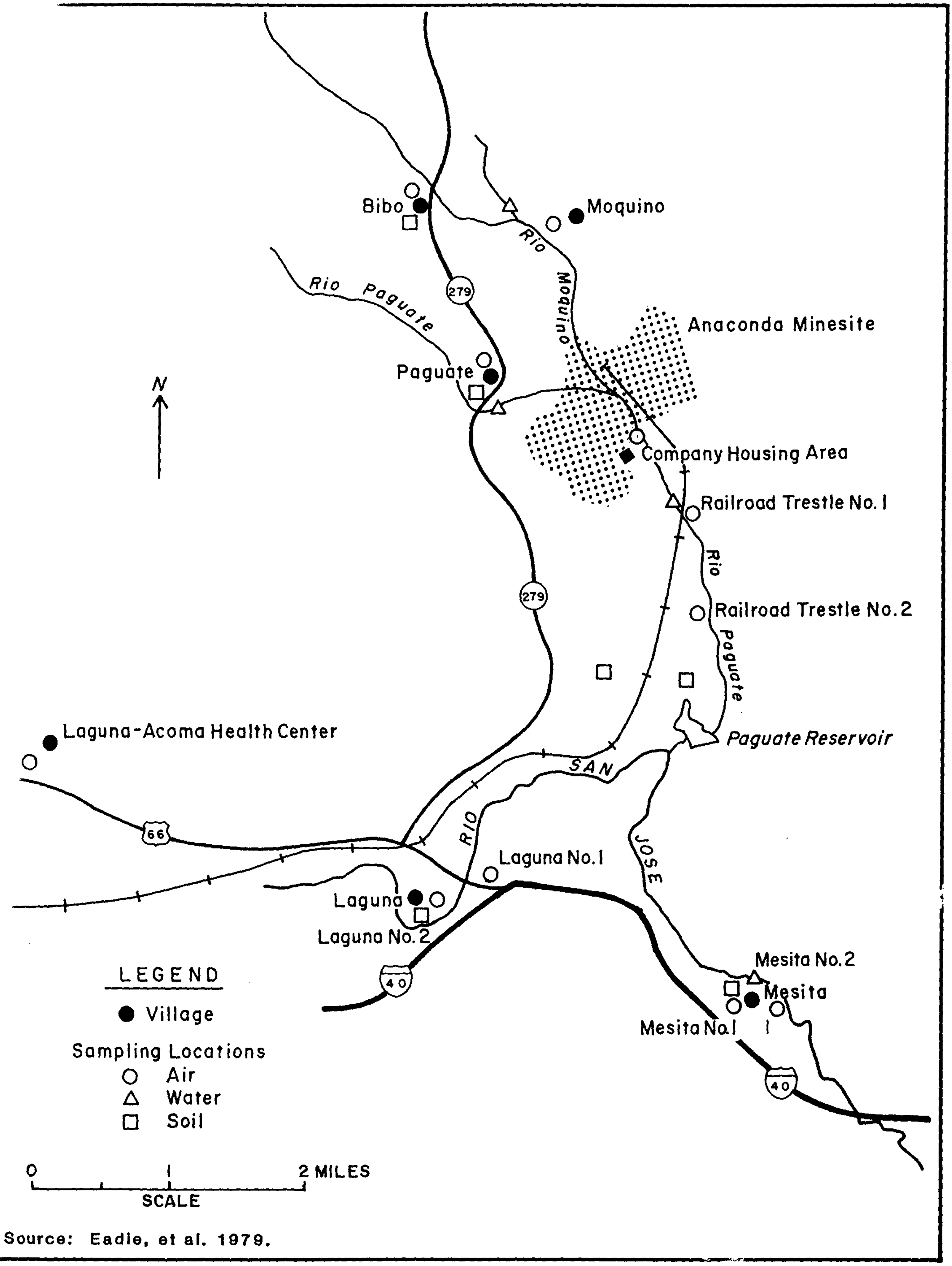

MAP 2-3 Radiological Sampling Locations in the vicinity of the Jackpile Mine

TABLE 2-17

AMBIENT OUTDOOR RADON-222 CONCENTRATIONS DURING JUNE 1976
(locations at or near the minesite)[a]
(picocuries per liter)

Location	Concentrations Maximum[b]	Minimum[b]	Average[c]
Company Housing Area	1.8 ± 0.23	0.25 ± 0.10	1.1 ± 0.34
Railroad Trestle No. 1 (below Co. Housing Area)	2.1 ± 0.26	Less than 0.12	0.99 ± 0.54
Railroad Trestle No. 2-- 1 mile south of Railroad Trestle No. 1	2.7 ± 0.24	0.44 ± 0.05	1.3 ± 0.50

Source: Eadie, et al. 1979.

Notes: [a]These locations are shown on Map 2-3.
[b]Result ± two-sigma counting error terms.
[c]Average result ± two-standard error terms (i.e., standard deviation of the sample population divided by the square root of the number of samples).

TABLE 2-18

AMBIENT OUTDOOR RADON-222 CONCENTRATIONS DURING JUNE 1976
(locations away from the minesite)[a]
(picocuries per liter)

Location	Concentrations Maximum[b]	Minimum[b]	Average[c]
Laguna No. 1 - (Old Laguna)	1.3 ± 0.18	0.2 ± 0.10	0.51 ± 0.28
Laguna No. 2 - (Training Building)	1.5 ± 0.39	0.14 ± 0.07	0.51 ± 0.29
Laguna-Acoma Health Center	1.6 ± 0.19	0.22 ± 0.11	0.63 ± 0.36
Bibo (Wellhouse)	1.4 ± 0.29	Less than 0.12	0.50 ± 0.23
Mesita No. 1 (Industrial Plant)	0.89 ± 0.33	0.18 ± 0.05	0.47 ± 0.31
Mesita No. 2 (Community Building)	1.7 ± 0.22	Less than 0.12	0.55 ± 0.49
Moqunio (Private Residence)	1.4 ± 0.23	Less than 0.12	0.54 ± 0.31
Paguate (Community Building)	0.75 ± 0.06	Less than 0.12	0.42 ± 0.14

Source: Eadie, et al. 1979.

Notes: [a]These locations are shown on Map 2-3.
[b]Result ± two-sigma counting error terms.
[c]Average result ± two-standard error terms (i.e., standard deviation of the sample population divided by the square root of the number of samples).

TABLE 2-19

RADON EXHALATION[a] AT THE JACKPILE-
PAGUATE URANIUM MINESITE
(picocuries per square meter per second)

Site	Exhalation Rate
Dump F	1.10
Dump G	4.15
Dump L	2.57
Dump K	2.70
Average	2.63
Typical background	1
EPA Mill Tailings Standard[b] (40 CFR 192)	20

Source: Anaconda Minerals Company 1982c.

Notes: [a] Data taken between October 1, 1980, and December 31, 1981, by Anaconda Minerals Company.
[b] Refer to Table 2-12.

TABLE 2-20

RADON EXHALATION ON THE LAGUNA RESERVATION
(picocuries per square meter per second)

Site	Exhalation Rate
Railroad Trestle	0.09
Old Laguna Ball Field	0.07
Jackpile Dump	
Old	0.4
New	0.6
Laguna Training Center	0.2
Paguate	0.3
Average	0.5
EPA Mill Tailings Standard[a] (40 CFR 192)	20

Source: Eadie, et al. 1979.

Note: [a] Refer to Table 2-12.

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TABLE 2-21

AREA AIRBORNE CONCENTRATION OF RADIOACTIVE PARTICULATES
(picocuries per cubic meter)

Location	Uranium (U-238)	Thorium (Th-230)	Radium (Ra-226)
Near Minesite[a]			
Bibo	0.00040	0.000320	0.00019
Mesita	0.00032	0.000180	0.00037
Old Laguna	0.00029	0.000085	0.00017
Average	0.00034	0.000200	0.00024
Offsite[b]			
Grants, NM	0.00120	0.001700	0.00075
Chicago, Ill.	0.00012	0.000045	--
New York State	0.00040	--	--
New York City	0.00008	--	--
NCRP-45 Background[a]	0.00012	0.000045	0.00010
Standards[a]			
Soluble	3.0	0.08	3.0
Insoluble	5.0	0.30	2.0

Sources: [a]Eadie, et al. 1979.
[b]Momeni, et al. 1983.

TABLE 2-22

MINESITE AVERAGE AIRBORNE CONCENTRATION OF RADIOACTIVE PARTICULATES
October 1980-December 1981
(picocuries per cubic meter)

Location	Uranium-Natural[a] (U-Nat)	Thorium (Th-230)	Radium (Ra-226)
Dump F	0.0016	0.0024	0.0014
Mine Vent	0.0092	0.0023	0.001
West Gate	0.0044	0.0023	0.0012
Well No. 4	0.0110	0.0024	0.0012

Source: Anaconda Minerals Company 1982c.

Note: [a]Uranium-natural is not the same as uranium-238 in Table 2-21. Standards for uranium-natural are 5 picocuries per cubic meter (soluble and insoluble).

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Water

The concentrations of uranium (U-234, U-235 and U-238) and of radium (Ra-226), gross alpha, and beta activity in samples of water from four wells on the Laguna Indian Reservation are listed in Table 2-23. The average concentrations for these wells are 0.3 picocuries per liter (pCi/l) Ra-226, 0.4 pCi/l U-234 , 0.1 pCi/l U-235, and 0.6 pCi/l U-238. These concentrations are within drinking water standards and are typical of values reported for public water supplies in the United States. In a recent work, Kriege and Hahne (1982) surveyed Ra-226 concentrations in community water supplies in 625 towns in Iowa. The range of average Ra-226 concentrations was 0.1 to 48 pCi/l. In an earlier study (Hursh 1953), the range of Ra-226 concentrations across the nation was found to be from 0.09 pCi/l in raw water and 0.08 pCi/l in tap water in Los Angeles, California, to 65.4 pCi/l in raw water and 57.9 pCi/l in tap water in Joliet, Illinois.

Surface waters are not regularly used for human consumption in the Paguate-Laguna area; however, part of surface water passing through the minesite collects downstream in Paguate Reservoir. Water from this reservoir is drunk by livestock, so a potential pathway exists for indirect exposure.

Table 2-24 shows the concentrations of radioactive elements in the Rios Moquino and Paguate. Radium concentrations increase about 10 times as the rivers flow through the minesite, while uranium concentrations increase almost 30 times. In both cases, these increased concentrations are still far below the drinking water standards. The increased river concentrations show up in Paguate Reservoir, although the radium concentration in the reservoir is only about a third the level of the radium in the river at the south boundary of the minesite.

As described in the Hydrology section of this chapter, four major ponds have formed at the minesite as the result of ground water seepage into the pits. All ponds have elevated levels of radium-226, from 1.6 to 8 times the drinking water limit of 5 pCi/l. However, uranium concentrations are below the New Mexico ground water limit of 5 milligrams per liter (No federal drinking water standard exists for uranium). The concentration of radium-226 in the ponds increased 170 percent from December 1982 to February 1986. The increasing levels of radioactive constituents are probably due to concentration by evaporation.

Ingestion

Radiation doses by ingestion normally result from consumption of food and/or water contaminated with radionuclides. The water pathway has already been discussed; this discussion is limited to food pathways.

TABLE 2-23

RADIOACTIVE ELEMENTS IN GROUND WATER FROM FOUR WELLS ON THE LAGUNA INDIAN RESERVATION[a]

Well	Element	Concentration (pCi/1 ± SE) [b]
Mesita No. 1 (BIA)	Gross alpha	5 ± 6
	Gross beta	5 ± 5
	Ra-226	0.2 ± 0.1
	U-234	1.3 ± 0.8
	U-235	0.4 ± 0.4
	U-238	1.3 ± 1.0
N.Y. No. 1	Gross alpha	3 ± 5
	Gross beta	7 ± 5
	Ra-226	0.3 ± 0.1
	U-234	0.5 ± 0.3
	U-235	0.0 ± 0.2
	U-238	0.9 ± 0.4
Well No. 1 Paguate	Gross alpha	3 ± 5
	Gross beta	3 ± 5
	Ra-226	0.4 ± 0.1
	U-234	0.1 ± 0.2
	U-235	0.1 ± 0.1
	U-238	0.1 ± 0.2
Well No. 2 Paguate	Gross alpha	0 ± 7
	Gross beta	2 ± 4
	Ra-226	0.2 ± 0.2
	U-234	-0.3 ± 0.5
	U-235	0.0 ± 0.2
	U-238	0.0 ± 0.2

Source: Momeni, et al. 1983.

Notes: [a] The EPA's national standards for community water systems are 15 picocuries per liter for gross alpha and 5 picocuries per liter for radium (40 CFR Parts 100 to 399). The NRC's maximum permissible concentrations (above background) in unrestricted areas are 4×10^4 picocuries per liter for U-238, and 3×10^4 picocuries per liter for U-234 and U-235 (10 CFR Parts 0 to 199).

[b] Picocuries per liter ± SE (standard error of measurement).

TABLE 2-24

RADIUM AND URANIUM IN SURFACE WATERS IN AND NEAR THE MINESITE

Location	Ra-226[a]	Natural Uranium[b]
Rio Paguate (upstream)	0.35	0.006
Rio Moquino (upstream)	0.28	0.008
Ford Crossing (downstream)	3.73	0.239
Paguate Reservoir	1.03	0.236

Source: Momeni, et al. 1983.

Notes: [a]Measured in picocuries per liter.
[b]Measured in milligrams per liter.

Pueblo of Laguna families or groups of families have small farming operations or gardens to supply produce for personal use. Sheep and cattle are also raised for food.

No radiological analysis of meat from locally raised animals has been done. However, the U.S. Environmental Protection Agency (Eadie, et al. 1979) has collected and analyzed samples of cucumbers and onions (Table 2-25).

Previously reported analyses of vegetables from elsewhere in the United States indicate a radium-226 content of less than 0.002 picocuries per gram (pCi/g) (Hallden, et al. 1963). Welford and Baird (1967) report a total uranium content for vegetables of 0.00053 pCi/g. The radioactive content of the cucumbers from the EPA's study is essentially comparable to these reported "typical background" values, with the exception of radium-226. The uranium content of onions was high compared to the values reported by Welford and Baird (1967).

Studies of radioactivity in rangeland vegetation in the Thoreau-Crownpoint area, New Mexico, have found radium-226 levels as high as 0.74 pCi/g and thorium-230 levels up to 0.50 pCi/g (Mobil Oil Corp. 1980). As with radioactive particulates (refer to the previous section of this chapter), this increased radioactivity level may be a natural phenomenon caused by the presence of ore-bearing formations or a result of many years of mining activities in the San Juan Basin.

Vegetative sampling of reclaimed dumps within the minesite have shown radium-226 levels ranging from 0.16 to 1.59 pCi/g, uranium (natural) levels from 0.76 to 7.13 ug/gm and thorium-230 levels from 0.43 to 2.56 pCi/g. Refer to the Flora section of this chapter for a complete analysis of radiological constituents in vegetative material on reclaimed waste dumps.

TABLE 2-25

RADIOACTIVITY IN VEGETABLES FROM THE LAGUNA RESERVATION[a]
(picocuries per gram)

Element	Cucumber	Onion
Radium-226	0.11 $\pm$ 0.011	0.047 $\pm$ 0.0083
Uranium-234	0.00018 $\pm$ 0.000032	0.026 $\pm$ 0.002
Uranium-235	Less than 0.000011	0.0011 $\pm$ 0.00034
Uranium-238	0.00013 $\pm$ 0.000027	0.027 $\pm$ 0.0021
Thorium-230	0.0032 $\pm$ 0.00049	0.035 $\pm$ 0.0052
Thorium-232	0.00042 $\pm$ 0.000091	0.039 $\pm$ 0.0057

Source: Eadie, et al. 1979.

Notes: [a]Concentration $\pm$ two-sigma counting error

HYDROLOGY

Surface and ground water quality data have been summarized in this EIS. Complete data is available for review at the BLM Albuquerque District Office, Rio Puerco Resource Area.

Surface Water

Rios Paguate and Moquino

The minesite and surrounding areas are drained by the Rios Paguate and Moquino, which begin on the slopes of Mount Taylor northwest of the minesite (Map 1-1, Chapter 1). The Rio Paguate is joined by the Rio Moquino near the center of the minesite (Figure 2-12). Below this confluence, the Rio Paguate flows southeasterly into Paguate Reservoir before joining the Rio San Jose 5 miles below the minesite. The Rio San Jose flows into the Rio Puerco, a major tributary to the Rio Grande, about 25 miles southeast of Laguna. The Rio Paguate watershed above the mine includes 107 square miles of drainage area, 68 percent of which is drained by the Rio Moquino. In and above the minesite, both rivers flow on alluvium that is at least 20 feet to more than 60 feet thick.

The Rio Paguate has been rechanneled for more than 2,000 feet downstream from its entrance to the minesite. Channel characteristics (sinuosity and gradient--refer to the Glossary) of the relocated stretch are the same as those of the premining Rio Paguate.

FIGURE 2-12 CONFLUENCE OF RIOS PAGUATE AND MOQUINO

The Rio Moquino has been extensively modified over a 4,000-foot segment immediately above its confluence with the Rio Paguate. Waste material has been dumped into the original channel on both sides, straightening the course of the meandering stream. Premining channel characteristics of sinuosity and gradient were 1.9 and .007, respectively, while those of the present Rio Moquino are 1.1 and .01, respectively.

The mean daily discharge of the Rio Paguate at the south end of the mine is 1.2 cubic feet per second (cfs), about half of which is supplied by surface discharge of ground water (base flow). Both the Rios Paguate and Moquino lose water from the points where they enter the mine to near their confluence. This loss is probably a response to dewatering of the mine. In the area of the confluence, both streams gain water from ground water discharge. Measurements at various times have shown that the streams gain between 43 and 135 gallons per minute (gpm) as they run through the minesite, while at other times they show a net loss of 83 gpm (Hydro-Search 1981). At the minesite, both streams usually flow all year (perennially); however, below the minesite, the Rio Paguate becomes intermittently dry (it is ephemeral).

Flow in the Rios Paguate and Moquino is generally moderate from January to March, elevated in March and April, low during the summer months, and moderate from October through December. Short-term peak flows occur in the summer in response to thunderstorms. The highest flow recorded on the Rio Paguate was estimated to be 2,300 cfs (USDI, Geological Survey 1976). Flood estimates of peak discharges at the southern mine boundary are 1,520 cfs for a 5-year flood; 6,290 cfs for a 100-year flood; and 10,500 cfs for a 500-year flood.

The chemical quality of the Rios Paguate and Moquino generally degrades as the rivers flow from their sources toward the Rio San Jose. This degradation is due to the geologic materials traversed by the streams, and to the influences of man. Data on premining water quality is nonexistent.

Water in the Rio Moquino is a sodium-calcium-magnesium-sulfate type (i.e., it is dominated by these constituents), and has a total dissolved solids (TDS) content of about 2,500 milligrams per liter (mg/l). Water in the Rio Paguate above the Rio Moquino is a magnesium-bicarbonate type, with TDS content of about 600 mg/l. Below the confluence of the streams, the water in the Rio Paguate is of the same type as in the Rio Moquino with TDS of about 1,600 mg/l. Measured pH values of Rios Paguate and Moquino waters within the minesite range from 7.4 to 8.5 (Hydro-Search 1981).

Ponding in Open Pits

Because the Jackpile Sandstone is a major bedrock aquifer in the areas, it excavation in the open pits during mining has resulted in significant ground water seepage into the pits. A large spring on the Rio Paguate side of the North Paguate Pit is flowing at about 100 gallons per minute into the pit. During mining operations, this water was used for dust suppression on roads, so the ponds were small. However, since mining has ceased, the water level in the pits has been increasing, and water depths averaging 18 feet deep have been recorded within the major ponds that have formed in each of the three pits. The surface water drainage area for water collecting in the pits is about 2 square miles. About two-thirds of the pond water is derived from ground water seepage, and one-third from runoff. The pits presently contain 36 acres of water surface and store about 455 acre-feet of water volume. The salt load collected in the pits is about 130 tons annually.

The quality of water in the ponds in the open pits is poor. Water quality analyses were taken over a 3-year period (end of 1974 to end of 1977) from the P-10 and Rabbit Ear holding ponds (Hydro-Search 1979).

These two ponds have since been drained; however, their analysis gave an indication of pit water conditions.

The P-10 pond contained water pumped from underground mine workings in the Jackpile Sandstone. As could be expected, the water was of the same type as Jackpile aquifer water and was chemically indistinguishable from the ground water.

The Rabbit Ear pond contained water pumped from pit seepages. This water was of much poorer quality than the ground water, due in part to concentration by evaporation. It was a sodium-sulfate-type water that increased in concentration over the 3-year period.

Total dissolved solids ranged from 1,500 to 4,900 milligrams per liter (mg/l), with sulfate values from 1,000 to 3,200 mg/l (New Mexico standards are 1,000 mg/l and 600 mg/l, respectively). The pH ranged from 8.1 to 8.6.

Other analyses of water ponded in the three mine pits were conducted in December of 1982 (Dames & Moore 1983). These tests found TDS values from 900 to 3,300 mg/l, sulfate values from 540 to 2,270 mg/l, and a pH range of 6.9 to 8.4 The high and low pH values came from the Jackpile pit; the low values were found in the southern part of this pit, and the high values occurred in the northern part.

More recent analyses (BIA 1984) have been completed on pond waters taken from the same locations as the December 1982 samples (Table 2-26). This series of tests has shown the evaporative concentration of pond waters is causing an annual increase in water conductivity ranging between 300 and 2,000 micromhos per centimeter per year (umho/cm/yr), an average of 975 umho/cm/yr. Sulfate is increasing at an average rate of 565 mg/l per year. The TDS has increased over 900 mg/l since the earlier samples at the Jackpile pit.

Water Use

Surface waters from the Rios Paguate and Moquino are used for irrigation upstream from the villages of Paguate and Seboyeta, respectively. Surface water is also consumed by livestock at Paguate Reservoir, and on the Rio Paguate between the reservoir and the minesite at points of access. The incidence of human consumption of surface waters from the Rio Paguate Basin is not known.

Sulfate concentration is the limiting factor for use of water in most of the mine area. The water in the Rio Moquino is high in sulfate before it reaches the minesite; this high-sulfate water also dominates the water quality in the Rio Paguate below its confluence with the Rio Moquino. It is within the range acceptable for livestock use and may even be used for irrigation of crops semi-tolerant to salinity, but is not recommended for human consumption.

TABLE 2-26

SELECTED SURFACE WATER QUALITY DATA
DISSOLVED CONSTITUANTS THAT EXCEED NATIONAL DRINKING WATER STANDARDS
(Concentrations in mg/l unless otherwise noted)

Location [a]	Date	TDS	Sulfate	Sodium	Selenium	Boron	Ra-226 (pCi/l)
EPA Standard	--	500	600	250	0.010	0.75[b]	15.0
Rio Paguate Upstream	4-86	546					
Rio Moquino Upstream	4-86	1,294	650				
Rio Paguate above Confluence	4-86	562					
Rio Moquino above Confluence	4-86	1,490	837				
Rio Paguate at Ford Crossing	4-86	1,155	699				
Paguate Reservoir	4-86	1,456	559				
Pond V - South Paguate Pit	2-86	1,803	924	566			21.1
Pond W- North Paguate Pit	2-86	4,297	2,764	515	0.104	0.81	36.0
Pond Y - South Jackpile Pit	2-86	1,834	1,132	469	0.026	0.97	18.0
Pond 2 - North Jackpile Pit	2-86	5,920	3,888	1,173		1.05	16.1

Sources: Anaconda Minerals Company 1986, BIA 1986

Notes: [a] See Visual A for locations
[b] Boron limit for irrigation use

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Above the confluence and within the minesite, water of the Rio Paguate is of good quality. The stream is designated by the New Mexico Water Quality Control Commission for the following uses: domestic water supply, fish culture, high quality coldwater fishery, irrigation, livestock and wildlife watering, and secondary contact recreation. This water is within the range acceptable for livestock use and irrigation, but due to occasional increases in sulfate it is considered unpalatable for human consumption.

Although the ponds in the pit bottoms are a consequence of mining activities and were not planned for livestock use, irrigation, or human consumption, incidental unauthorized use of the pond water could occur.

Concentrations of some elements fail to meet standards established by the Environmental Protection Agency (EPA--40 CFR, Part 141.11; 40 CFR, Part 143.3) for public supply, agricultural, and industrial use. Table 2-26 lists surface water quality data from sample sites (Visual A).

Ground Water

Water-Bearing Units (Aquifers)

The ground water characteristics of the sedimentary strata exposed in the Laguna area are given in Table 2-27. Stratigraphic descriptions are found in the Geology section of this chapter.

Data from 17 wells within the lease area has been used to characterize the quality of the ground water. Typical Jackpile Sandstone water is a sodium-sulfate-bicarbonate type of pH 6.5 to 8.3. TDS concentrations range from 600 to 2,600 mg/1. Minor chemical constituents are generally at low concentrations.

Alluvial water at the minesite has higher calcium, magnesium and TDS levels (average 1,332 mg/1) compared to typical Jackpile Sandstone water (Hydro-Search 1981).

Ground Water Recharge and Flow in the Pit Areas

Ground water flow in the minesite area converges on the Rio Paguate and Rio Moquino. Data indicates that most of the flow into the area is from locations high on the flanks of Mount Taylor to the west, and probably from Mesa Chivato to the north (Hydro-Search 1981). Much of the flow from the west is intercepted by the North and South Paguate pits. Local flow from the east probably comes from Gavilan Mesa. Flow in the southeast part of the mine is not defined, but is probably toward the Rio San Jose to the southeast.

Seepage is obvious on the walls of the North Paguate, South Paguate and Jackpile pits at elevations much higher than ponds at the pit bottoms. One large seep in the North Paguate pit flows approximately 100 gallons per minute. The ponds are also below water levels in adjacent wells. Potentiometric surface contours indicate ground water seepage

TABLE 2-27

GROUND WATER CHARACTERISTICS OF THE STRATIGRAPHIC SECTION AT THE JACKPILE-PAGUATE MINE

Formation	Yield and Water-Bearing Properties[a]
Alluvium	Yields of 15 to 90 gpm; quality good
Colluvium	Mostly above water table
Mancos Shale Dakota Sandstone	Yields from Tres Hermanos Sandstones range from 5 to 20 gpm; quality fair to good
Morrison Formation	
Jackpile Sandstone Member	Principal bedrock aquifer; yields of 8 to 34 gpm; quality fair to poor; under confined conditions
Brushy Basin Member	Yields of 25 to 100 gpm from sandstone lenses; quality fair to poor
Westwater Canyon Member	Yields up to 5 gpm; quality poor
Recapture Member	Not known to yield water to wells
Bluff Sandstone	Yields to 20 gpm reported; quality poor
Summerville Formation	Not known to yield water to wells
Todilto Formation	Not known to yield water to wells
Entrada Sandstone	Yields of 4 to 10 gpm; quality poor

Source: Modified from Dames and Moore 1976.

Notes: [a] Abbreviations: gpm = gallons per minute; TDS = total dissolved solids; ppm = parts per million; SO_4 = sulfate. Water Quality: Good = TDS below 500 ppm, SO_4 below 250 ppm; Fair = TDS 1,000 to 500 ppm, SO_4 300 to 250 ppm; Poor = TDS above 1,000 ppm, SO_4 above 300 ppm.

into the pits. About two-thirds of the water in the pits is thought to be from ground water seepage, the remainder is from surface runoff. Water loss is by evaporation, and when the mine was operative, by use of this ponded water to wet roads. Salt balance and water balance calculations suggest that 150 acre-feet, or one-third of the water contained in the ponds, is gained by, and then evaporated from, the ponds each year. Premining ground water, however, would have flowed across and through the present pit areas, in a northeasterly and easterly direction at the North and South Paguate pits, and in a generally southwesterly direction at the Jackpile pit (Hydro-Search 1981).

Interpreting potentiometric surface contours in the Gavilan Mesa area is highly speculative. The most plausible direction of flow is from Gavilan Mesa, the highest local area, toward the northwest, west, and southwest.

Hydro-Search (1979) describes water gains to the Rios Paguate and Moquino of about 20 gallons per minute near their confluence, and water losses from the Rio Paguate in the segment from the Village of Paguate to 1,000 feet above the confluence. The potentiometric surface contours indicate that water gains come from the Jackpile Sandstone, which discharges into the Rios Moquino and Paguate near the confluence. The contours do not show ground water mounding under the Rio Paguate upstream from the confluence. It is likely that the waste rock underneath the modified Rio Paguate in this area is permeable enough to drain water losses from the river without ground water mounding (refer to the Glossary).

Little data is available to accurately describe water flow through pit backfill and waste dumps. A well drilled into the Jackpile pit backfill at the southwest end of the pit determined that the water table elevation was 5,968 feet in August 1981. The direction of flow could not be determined. A well drilled into backfill at the north end of the South Paguate pit determined a water table altitude of 5,981 feet in June 1981. This water likely flows south to the low point of the South Paguate pit, north towards the Rio Paguate, or both. Pit backfill above the water table may become partly saturated after major storms.

The recharge rate in the Rio Paguate drainage basin is about 0.1 inches per year, based on the calculated sum of base flow and underflow through alluvium. Rates may vary locally with elevation, ground slopes, rock type, and distribution of alluvial and aeolian deposits. For instance, recharge is probably greater in alluvium at valley bottoms than it is on exposed bedrock. Regional recharge to rocks at the mine is from high areas on the flanks of Mount Taylor to the west, and probably from Mesa Chivato to the north. Some recharge may occur locally at the mine, especally on Gavilan Mesa, where it is likely that a perched water table exists in fractured Mancos Shale and Dakota Formation. This water likely recharges the underlying Jackpile Sandstone aquifer in this area.

The hydraulic conductivity is about 22 feet per day for the undisturbed alluvium, and 0.3 feet per day for the Jackpile Sandstone and sandstone lenses of the Brushy Basin Member. Most of the local water flow in alluvium and the Jackpile Sandstone discharges to mine pits, underground mines, and the Rios Paguate and Moquino. Permeability and hydraulic conductivity of the disturbed material and existing backfill is highly variable. Among ten recent well tests in backfill, one yielded a permeability value of 2,700 feet per day, one a value of 13 feet per day, and the remainder between 1.2 and 6.2 feet per day (Dames & Moore 1983).

Flow in Waste Dumps

Most precipitation falling on waste dump tops at the minesite either evaporates, infiltrates uniformly into the dump materials, or collects in depressions, dissipating by flowing vertically downward into cavities (pipes). No seepage faces have been observed at the bases of dumps during dry weather, indicating that saturation is of limited duration, or that flow may be vertical through the dump bases to the underlying alluvium. Hydraulic conductivity and local soil piping may promote rapid infiltration and discharge of water from high rainfall events, preventing long-term saturation. Cross-sectional flow analyses of precipitation infiltration into waste piles confirm that the formation of a saturated zone in waste dumps is unlikely because of evaporation of surface and near-surface water, and, to a lesser degree, the effects of high hydraulic conductivity in draining off water from large storms.

Water Use

Ground water on the Laguna Pueblo is used for livestock, public supply and industry. As of 1975, the pueblo maintained 52 stock wells on tribal lands; these wells averaged less than 5 gallons per minute (gpm). The majority of the population is served by a central water supply system, extending from Seama to Mesita. The system, which has a combined pumping capacity of 385 gpm, receives its water from wells drilled into alluvium of the Rio San Jose at the western end of the pueblo, at New Laguna, and at Mesita (Lyford 1977). The Village of Paguate obtains water from two wells (averaging 90 gpm) located in the alluvium of the Rio Paguate upstream from the minesite.

Industrial water usage at the minesite during mining averaged 17 gpm, mostly from Well 4 in the Jackpile Sandstone. Approximately 200 gpm were removed by dewatering of the underground workings. One water well, the IR-Test 9 in Township 10 North, Range 5 West, Section 26, exists in the alluvial aquifer down-gradient from the mine; this well is plugged and abandoned (Lyford 1977).

Table 2-28 lists ground water quality data from sample sites (Visual A) where element levels were found to exceed EPA drinking water standards.

EROSION

Arroyo Headcutting

Many arroyos in central New Mexico are actively eroding by headward cutting, a process by which the arroyo bed forms a near-vertical face

TABLE 2-28

SELECTED GROUND WATER QUALITY DATA
DISSOLVED CONSTITUENTS THAT EXCEED NATIONAL DRINKING WATER STANDARDS
(Concentrations in mg/l unless otherwise noted)

Sample Identification[a]	SO_4	Na	Cd	Pb	Fe	Mn	B	Co	Ra-226 (pCi/l)
EPA Standard	600	250	0.01	0.05	0.30	0.05	0.75	0.01	15.0
M-1P		305				0.085			22.0
M-2P						0.09		0.02	
M-4	1,230	294			0.44	0.09			
M-5		340	0.16	0.13		0.085			
M-6		295						0.02	
M-8		305				0.11			
M-10P		390						0.06	
M-14P	920	418			0.64	0.39		0.07	
M-16P	672	390			0.41	0.19		0.06	
M-22		305				0.21			
M-23		380							
M-24P	2,010	915				0.74	0.96		
B	5,560	1,400			139.00	1.7	1.2	0.2	
C	3,540					0.5			
D	2,010	1,160			0.34	0.17			

Sources: Hydro-Search 1981; Dames and Moore 1983; USDI, BIA 1984.

Note: [a] Refer to Visual A for location.

(headcut) that migrates upstream as erosion of the bed continues (Figure 2-13). In response to lowering of the bed of the main arroyo, headcuts often migrate up tributary streams, and significant amounts of soil loss result.

Arroyo headcuts near the minesite have moved as far as 350 feet during the 43 years between 1935 and 1978. Aerial photography indicates that headward cutting of arroyos was an active premining process. The main mechanisms responsible for headcutting at the minesite are rapid surface flow from floodwaters and, more importantly, piping. Caving of arroyo banks results when piping occurs near arroyos. At the minesite, piping is extensive at the most unstable headcuts.

Several areas of arroyo instability exist at the minesite, the most important of which are: (1) south of I, Y, and Y2 dumps; (2) west of dump FD-3; and (3) west of the airstrip (Visual A). The westernmost arroyo headcut system south of dumps I, Y and Y2 moved 100 feet upstream between 1935 and 1978. The amount of headward cutting on the arroyo just west of J dump could not be determined due to burial of the arroyo by the dump. This general area is highly unstable, and has 10 to 15 active headcuts that move by piping-induced bank caving. Because these headcuts have threatened the haul road at the base of I, Y and Y2 dumps, Anaconda has placed artificial fill at headcuts and constructed drainage diversions. The fill has slowed headward erosion, while the diversions have accelerated such erosion. Surface erosion and piping have continued to act in and around these modifications, making them only temporary measures.

The southwest-flowing arroyo west of dump FD-3 is discontinuously entrenched, and has several headcuts (Figure 2-14). The segment of this arroyo downstream from the road is very unstable due to piping and bank caving. The headcut at the road has been treated with artificial fill, but a bypass headcut that will threaten the road is forming. Headcuts upstream from this area are held up by resistant sandstone, which renders them relatively immobile.

The arroyo headcut west of the airstrip moved upstream 350 feet between 1935 and 1978. This rapid movement occurred in easily erodible, thick alluvium; however, the headcut is now located in apparently less erodible alluvium, with only minor piping present. Anaconda has dumped artificial fill at the headcut located at the road, and the fill seems to be successfully inhibiting further movement.

As a consequence of mining activities, three arroyos at the minesite have been blocked by waste dumps or protore stockpiles (Visual A). For all reclamation proposals except Anaconda's 1985 plan, the drainage blocked by waste dump J and protore stockpiles SP-17BC and SP-6-B will be unblocked during reclamation. Under Anaconda's 1985 plan, these piles would remain in place. The drainages north of waste dumps F and FD-1 will remain blocked. The drainage areas upstream from these blockages measure 0.9 square miles and 1.7 square miles, respectively. These

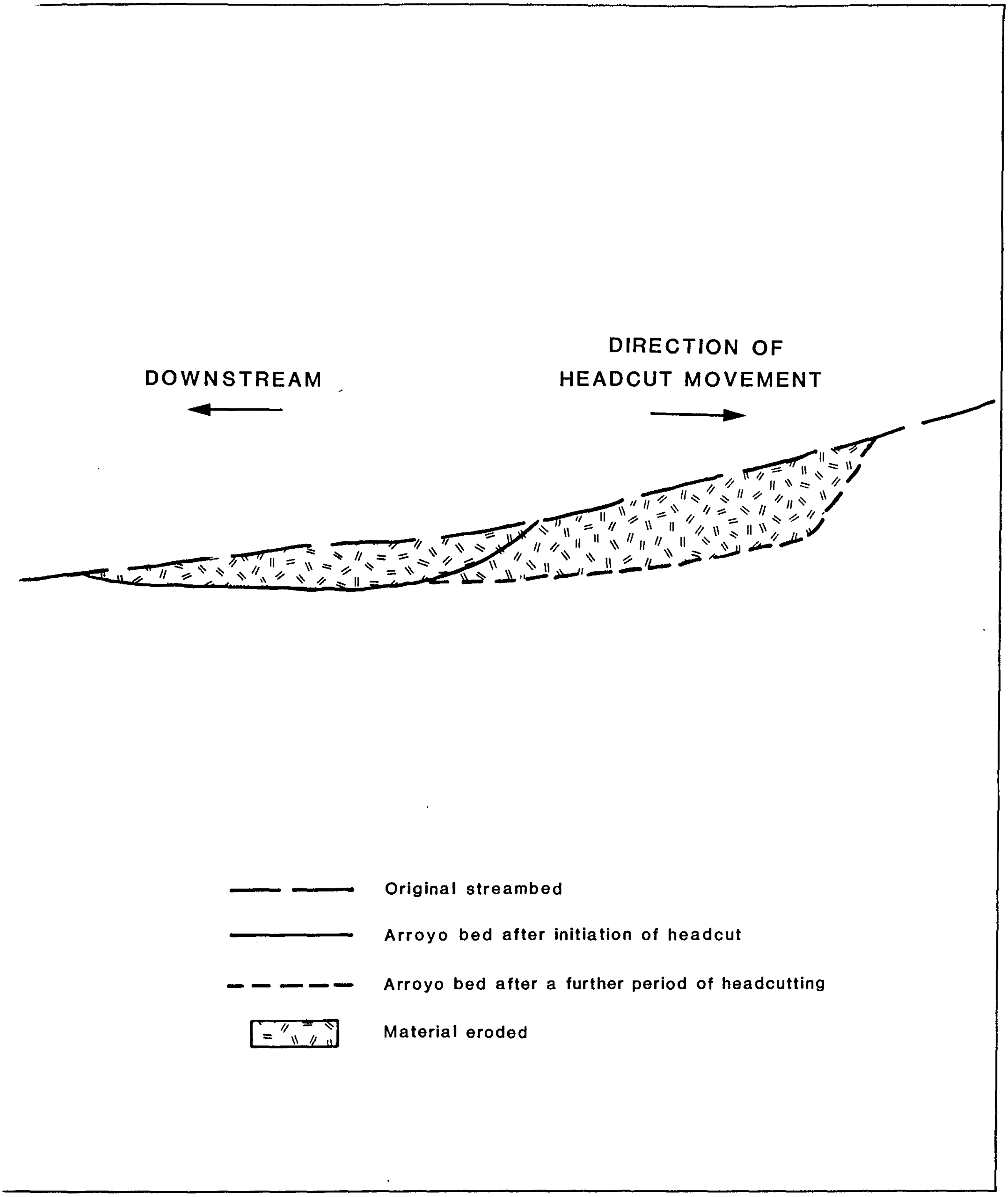

FIGURE 2-13

Cross-sectional, schematic diagram of arroyo headcut migration.

FIGURE 2-14 ARROYO HEADCUTTING NORTH OF FD-3 DUMP

arroyos are normally dry, except during and immediately after thunderstorms when water ponds at the blockages. In general, the ponded water is quickly lost to infiltration and evapotranspiration. Up to 16 feet of water could be ponded north of F dump after a 24-hour rainfall (100-year flood). A maximum of about 25 feet of water could be ponded north of FD-1 dump after such a rainfall. Both blockages are sufficiently high to hold such a quantity of water.

Sedimentation in Paguate Reservoir

Sediment has nearly filled Paguate Reservoir since construction of the dam in 1940. Dames and Moore (1980) calculated that the rates of deposition in the reservoir during 1940-49 and 1949-80 were 71 acre-feet per year and 22 acre-feet per year, respectively. The higher rate of deposition from 1940 to 1949 was due to:

1. Greater sediment transport due to above-normal precipitation; and, more importantly,

2. Much greater efficiency of sediment entrapment in the early years. Efficiency would have been 100 percent just after construction and would have decreased as sediment filled the reservoir.

Based on the lower rate, the volume of sediment deposited since mining began (1952) is 620 acre-feet, or 47 percent of the total 1,333 acre-feet per year accumulated (Dames and Moore, 1980).

Stream Stability

Above the Rio Moquino/Rio Paguate confluence, the Rio Paguate is a non-meandering stream incised into alluvium from 33 to 69 feet deep. Aerial photographs show that essentially no lateral migration of the channel occurred from 1935 to 1951. Vertical change (incision or deposition) in the river bed has also been minimal (less than 2 feet), as no headcuts or mid-stream bars have been noted on the pre- and post-mining stream. Vegetation inside the main channel in 1935 and 1980 was dense and stable in appearance. These observations, taken together, suggest that this reach of the Rio Paguate had attained a stable state before mining. Because the channel characteristics of the relocated channel are similar to those of the pre-mining channel (see page 2-49), the stream should remain in a stable condition.

The Rio Paguate below the confluence is incised up to 65 feet into alluvium. This segment also showed essentially no lateral migration between 1935 and 1951, and vertical instability (headcuts or deposition) was not seen on pre-mining photographs and during field checks. This section of the Rio Paguate, like that above the confluence, apparently was stable in regard to lateral and vertical changes before mining (see page 2-49). Because present channel characteristics are similar to those existing before mining, the stream is expected to remain in a stable condition.

Dumping of mine waste material onto meanders has considerably straightened the Rio Moquino (see page 2-49). The stream, which is incised from 40 to 68 feet into alluvium, meandered with no evidence of vertical instability (incision or aggradation) before mining. The meander belt of the pre-mining stream was 400 feet wide. Lateral channel migration by this stream of up to 150 feet between 1935 and 1951, as well as historical lateral movement of up to 250 feet, has occurred at the minesite. These significant rates of lateral channel migration suggest that the pre-mining Rio Moquino meandered across its alluvial plain at the minesite with little resistance. Analysis of data from drill holes adjacent to the Rio Moquino confirms that, in most places, no geologic constraints exist to lateral channel movement. For the past several years, the river has not migrated laterally or incised vertically as shown by field checks. However, historical evidence indicates that this stretch of the Rio Moquino still retains a significant potential for lateral migration.

Waste Dump Slopes

The 32 waste dumps at the mine cover approximately 1,266 acres, or about 48 percent of the total disturbed area. The dump materials consist of Mancos Shale, Dakota Sandstone, and both barren and ore-associated Jackpile Sandstone. The waste dumps approximate the form of nearby mesas; that is, the majority of their areal extent is composed of relatively flat dump tops that abruptly change to steep slopes. The height of the waste dumps ranges from 20 to 230 feet, and the slope percentage varies from 31 to 102 percent. Table 2-29 gives slope percentage, length and height of the larger dumps.

TABLE 2-29

WASTE DUMP DIMENSIONS

Waste Dump	Slope[a] Percent	Height (feet)	Slope Length[b] (feet)
FD-2	73	230	423
FD-3	93	130	195
I[c]	31	50	206
I (Slope Segment 1)	37	72	120
I (Slope Segment 2)	39	25	40
I (Slope Segment 3)	34	11	20
N[c]	93	80	120
N	82	46	76
N	60	40	89
N2	69	30	58
R	102	25	35
South[c]	100	90	127
South	100	140	198
South	71	60	112
SP-1	82	31	51
SP-2	80	40	68
T	85	100	164
U[c]	82	60	100
U	82	60	100
V[c]	87	215	345
V	80	150	258
Y	80	115	196
Y2	82	150	249

Source: Anaconda Minerals Co. 1980.

Notes: [a] Slope percent = ratio of vertical height of the slope to the horizontal base length (not slope length) of the slope.
[b] Slope length = surface extent of slope measured from toe to crest.
[c] Measurements were made at more than one location on these waste dumps.

04000115

Reclamation attempts have been made on approximately 485 acres of 17 waste dumps (Anaconda Minerals Co. 1982). Waste dumps tops have been revegetated with varying success. Revegetation of dump slopes has failed because of steepness, length of slopes and resultant erosional soil loss. Most dump slopes have been cut by gullies greater than 8 feet wide and up to 13 feet deep. Dumps E, I, S, T and V have been severely gullied. Most of the larger gullies have been initiated by piping at dump crests and the resultant flow of water diverted from dump tops into pipes and down steep slopes. However, numerous smaller gullies have formed in the middle of dump slopes. This indicates the water velocities resulting from rainfall and runoff on steep slopes are sufficient to initiate gully erosion.

The existing rates of sheetwash and small rill erosion, calculated with the Universal Soil Loss Equation (USLE), range from 27 tons per acre per year to 105 tons per acre per year (Table 2-30). The USLE is an empirically developed equation which relates soil loss to amount, frequency, and intensity of rainfall, soil characteristics, length of slope, slope angle, vegetation or ground cover and erosion control practices. Cumulative gully erosion (calculated by measurement of gully dimensions) ranges from 4 tons per acre to 561 tons per acre, and the mean annual rate is 16 tons per acre per year. Total computed and measured erosion (sheetwash plus gully erosion) ranges up to 121 tons per acre per year (Table 2-30).

A positive correlation has been found between accelerated erosion and long, steep slopes. The least amount of calculated and measured erosion occurs on the most gentle slopes and also on those slopes that are covered by boulder-size rock debris. Therefore, the main factors controlling erosion on dump slopes are slope length, steepness, and surface roughness; of these, slope steepness and roughness seem to be most critical.

Piping is also an active feature at the minesite and can be expected to eventually occur on most waste dumps. Piping can initiate large gullies which are sources of rockfalls, earth slides and high velocity concentrated runoff. These gullies could also expose radioactive materials within the interior of dumps and thus increase the radiological hazards at the minesite.

AIR

Meteorology

Temperatures

Monthly mean temperatures at the meteorological station at the Village of Laguna range from the mid-30's (degrees Fahrenheit) in winter to the mid-70's in summer. Large annual and daily temperature ranges are characteristic, but extended periods of below-freezing temperatures are rare. Summer temperatures average in the upper 80's with occasional maximums over 100°F, but long spells of temperatures over 100° are unusual.

Precipitation

The mean annual precipitation at Laguna is 9.07 inches, about 61 percent of which occurs from June to September as rain, mostly from short, intense thunderstorms. Precipitation frequencies range, on the average, from 1.2 inches per 24-hour period every 2 years, to as much as 2.8 inches per 24-hour period every 100 years (U. S. Department of Commerce 1967). Annually, an average of 7.3 inches of snow is received, 60 percent of which occurs in December and January. Because of generally warm afternoon temperatures, snow rarely accumulates.

Evaporation

The mean annual pan evaporation (refer to the Glossary) at Laguna is about 70 inches, more than 60 percent of which occurs from May to September. Mean annual pan evaporation is about 61 inches more than mean annual precipitation, resulting in a net moisture deficit.

Moreover, months of greatest evaporation correspond to months of greatest rainfall, compounding aridity problems.

Winds

Winds in the mine area are generally of light to moderate intensities, with wind speeds greater than 15 miles per hour (mph) accounting for less than 11 percent of all occurrences. However, strong winds may accompany frontal storms during winter and spring months, and occur during intense summer thunderstorms. Average wind speeds are greatest during the spring months. Average wind speeds range from 5.3 mph from the east, to 11.6 mph from the west-northwest.

Surface winds at the mine occur primarily from the southeast and northwest. Nocturnal winds flow from higher areas to the west and northwest, at an average of 7 mph. The most frequent daytime winds are from the southeast. However, the strongest winds are northwesterly, with speeds averaging 13.5 mph.

Air Quality

Anaconda has four air quality sampling stations at the minesite. The samplers monitor suspended particulate levels and several radionuclides (discussed in the Radiation section of this chapter). The State of New Mexico operates an air quality monitoring station at Paguate village. No pre-mining data are available.

Particulates

Total suspended particulates (TSP) have been measured at the mine since 1973. Sampling techniques have varied throughout the monitoring program. Prior to 1979, an average of one 24-hour TSP sample per month was taken from the West Gate and Well 4 stations. Since 1979, one 168-hour sample has been taken each month at the four sampling stations.

The annual geometric mean and seven-day average of TSP values from 1979 to 1981 are presented in Table 2-31. These data show that TSP levels have mostly been within State of New Mexico standards. The general trend of decreasing TSP values from 1979 to 1981 may be due to decreased mining activity.

TSP data have also been obtained at the State air quality station at Paguate. The data has been collected from weekly 24-hour samples. For 1979 through 1982, the annual geometric means of TSP at this station were 79, 56, 59, and 35 micrograms per cubic meter ($\mu g/m^3$), respectively (Table 2-31); these compare to State and Federal standards of 60 and 75 respectively. Again, decreasing values may reflect decreased mining activity. Generally, TSP standards have been met both at Paguate Village and the mine, although the seven-day average and annual geometric mean standards have sometimes been exceeded.

Other Pollutants

Neither Anaconda nor the State has measured sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), or lead (Pb) levels at the minesite or Paguate Village. Because these constituents are associated with major point-source polluters and metropolitan areas with many automobiles, they are probably present in only trace amounts at the mine.

Anaconda conducted a brief monitoring program for nitrogen dioxide (NO_2) in February 1973, and found that 24-hour average concentrations ranged up to a maximum of 0.0079 parts per million. This is well below the New Mexico 24-hour average standard of 1.10 parts per million.

SOILS

Undisturbed Soils

Natural soils in the vicinity of the Jackpile-Paguate mine are shallow in most upland areas (generally less than 3 feet deep) and are significantly deeper in the valleys (up to 6 feet deep) because of alluvial deposition. The upland soils belong to the Penistaja-Travesilla-Rockland Association. The Penistaja soils occur on gently to strongly undulating valley slopes, and consist of shallow surface layers of brown, fine, sandy loam over subsoils of brown, sandy, clay loam. Below this horizon is a loam with lime concretions and a prominent lime zone below a depth of 40 inches. Travesilla soils, which are underlain by sandstone at shallow depths, occur on valley slopes and mesa tops. They are composed of a shallow surface layer of brown, fine, sandy loam underlain by a coarse-grained, sandy subsoil over sandstone bedrock. Rockland soils consist of a shallow, coarse-grained, sandy mantle of soil between outcrops on steep slopes.

Valley soils belong to the Lohmiller-San Mateo Association. Lohmiller soils, which are deep, fine-textured, and locally saline, occur on floodplains and swales. These soils have a brown, calcareous, clay loam topsoil underlain by brown, heavy clay, silty clay, or clay

TABLE 2-30

SHEETWASH AND TOTAL EROSION FOR SELECTED WASTE DUMP SLOPES
(tons per acre per year)

Waste Dump(s)	Sheetwash Erosion	Total Erosion[a]
A & B	61	77
C,D,E,F,G	53	68
FD-3	100	116
I	52	67
K	60	75
L (South)	39	55
N	50	66
N2	29	45
P1	34	50
P2	65	80
R	27	43
S (North)	60	75
South	91	107
T	77	92
U	56	72
V	105	121
Y	77	92
Y2	94	109

Source: BLM 1983.

Note: [a] Total erosion = sheetwash erosion + gully erosion.

TABLE 2-31

TSP DATA FOR THE JACKPILE-PAGUATE MINE, 1979-1981
(values in micrograms per cubic meter)

	Dump F	Mine Vent	West Gate	Well 4	Paguate
Range	2-172	2-62	2-101	2-96	--[a]
Annual Geometric Mean[b]					
1979	50	9	35	21	79
1980	29	9	28	32	59
1981	15	15	22	14	56
High Seven Day Average[c]					
1979	172	27	95	96	--
1980	98	62	101	72	--
1981	48	46	82	38	--

Source: BLM 1984.

Notes: a/The symbol -- reflects data not available.
b/State standard = 60
Federal standard = 75
c/State standard = 110

loams. San Mateo soils occur on floodplains and consist of a surface layer of brown, calcareous loam underlain by 5 feet or more of sandy and light clay loams.

Stockpiled Soils

Approximately 3.1 million cubic yards of topsoil material were stockpiled at the mine. These soils consist of some Lohmiller and Penistaja, but mostly Rockland types. The Rockland soils consist primarily of crushed Tres Hermanos Sandstone. The important chemical and physical properties to the Tres Hermanos Sandstone are indicated in Table 2-32. The stockpiled soils are situated at three different locations within the minesite (Figure 2-15).

Soil Borrow Site Characteristics

Soils at the borrow site (Visual A) are Lohmiller types, which include clay loams and sandy clay loams. These are deep, fine-textured soils that the U.S. Soil Conservation Service classifies as having fair permeability, fair to good salinity, good moisture-holding capacity, and fair to good organic matter content. Arsenic and selenium concentrations are low. Chemical and physical properties are given in Table 2-33.

FLORA

Within the 7,868-acre lease area there are presently three types of physical terrain successional situations:

Undisturbed Natural Vegetational Areas (4,727 acres)

These undisturbed portions of the lease area are characterized by broad mesas and plateaus separated by deep canyons, wide alluvial valleys and dry washes. Elevations range from 5,800 feet in the valley bottoms to 6,700 feet on the mesa tops. Three types of natural settings occur on the undisturbed terrain. Dominant topographic features and associated plant species are described as follows:

Valley Bottoms

Valley bottoms can be level, undulating or incised. They have deep soils that support shrub species such as fourwing saltbush, rabbitbrush, cholla and broom snakeweed. Prevalent grasses include alkali sacaton, galleta, feathergrass and red threeawn. Forbs that are plentiful include fleabane fireweed, sandverbena, stickleaf, paperflower, daisy and cutleaf primrose.

Only a small portion of the riparian habitat along the Rio Moquino was left undisturbed by mining activity. Plant species commonly found in this area include saltcedar, desert willow, Emory baccharis and rabbitbrush. Understory grasses include alkali sacaton, galleta, cane bluestem and western wheatgrass.

TABLE 2-32

CHEMICAL AND PHYSICAL PROPERTIES OF THE TRES HERMANOS SANDSTONE
[concentrations in parts per million (ppm)]

Calcium (Ca)	7,850
Magnesium (Mg)	1,465
Sodium (Na)	40
Potassium (K)	238
Phosphorus (P)	4.1
Nitrate (NO_3)	24.6
Iron (Fe)	.02
Zinc (Zn)	.25
Cadmium (Cd)	.28
Copper (Cu)	.5
Manganese (Mn)	18.0
Lead (Pb)	1.0
Mercury (Hg)	.005
Cobalt (Co)	.12
Chromium (Cr)	.05
Nickel (Ni)	.45
Arsenic (As)	.3
Selenium (Se)	.03
Chlorine (Cl)	15.7
pH	7.2
Organic matter	0.5 percent
Cation exchange capacity	8.8
Electrical conductivity	0.8 umhos/cm
Moisture content at field capacity	35.9 percent

Source: Los Alamos National Laboratories 1979.

FIGURE 2-15 TOPSOIL STOCKPILE TS-3

TABLE 2-33

CHEMICAL AND PHYSICAL PROPERTIES OF SOIL BORROW SITE

Selenium (Se)	<.1 ppm
Nitrate (NO_3)	14.38 ppm
Phosporus (P)	.20 ppm
Potassium (K)	133 ppm
Boron (B)	1.37 ppm
Arsenic (As)	<.2 ppm
pH	7.85
Organic matter	1.2 percent
Electrical conductivity	4.02 μhos/cm
Moisture - 1/3 Bar	24.1 percent
- 15 Bar	12.0 percent

Source: Ludeke 1983.

Mesa Slopes

Mesa breaks and sideslopes are steep and have shallow to moderately deep soils interspersed with rock outcrop. These sites are occupied by scattered woody plants which include one-seed juniper, feather indigobush, soaptree yucca and winterfat. Understory grasses include galleta, feathergrass, red muhly, red threeawn, blue and sideoats gramas, bottlebrush squirreltail and wolftail. Understory forbs include wild buckwheat, pinque, plains blackfoot and stickleaf.

Mesa Tops

Mesa tops are nearly level to undulating and have shallow rocky soils. These areas are generally dominated by a woody overstory consisting of one-seed juniper, soaptree yucca and rabbitbrush. Prinicipal grasses include galleta, feathergrass, Indian ricegrass, sideoats and blue gramas, red threeawn and bottlebrush squirreltail. Forbs include fleabane daisy, four o'clock and cutleaf primrose.

Surface Disturbed Areas Not Reclaimed (2,171)

These areas primarily consist of open pits, waste dumps, protore stockpiles, depleted ore stockpiles, topsoil stockpiles and miscellaneous support facilities. Vegetation is either absent in these areas or in a low successional state with a sparse scattering of pioneer plants.

Dumps created by overburden removal contain a mixture of waste materials. The most common geologic materials that form the dumps are Jackpile Sandstone, Tres Hermanos Sandstone and Mancos Shale. The basal unit of the Dakota Sandstone is very thin within the lease area and therefore does not constitute a major portion of the overburden materials. Table 1-4 in Chapter 1 lists the surface composition of each waste dump. With few exceptions, the internal composition is unknown. It should be noted that the surface area of disturbance had reached sizeable proportions before reclamation became an important consideration. Therefore, the need for surfacing areas with a viable growth medium brought about an examination of the overburden strata.

The ability of plants to grow on overburden materials varies with several chemical properties. The low pH of the Dakota Sandstone eliminates it as a suitable growth medium. The Jackpile Sandstone and Mancos Shale are low in several major nutrients and restrictively high in sodium content. Observations of dump sites with various geologic substrates left undisturbed for 20 years show the following vegetational establishment: Dakota Sandstone - no vegetation: Mancos Shale - plants rare, annual and perennial grasses, few shrubs; Tres Hermanos Sandstone - plants common, perennial and annual grasses and forbs, several shrub species.

As indicated, the Tres Hermanos Sandstone offers the best possibilities for plant establishment. However, in order to meet topdressing requirements, material may be required in addition to the

Tres Hermanos Sandstone presently stockpiled at the mine. A topsoil borrow location, comprising approximately 44 acres, has been identified in the north - central portion of the lease area as the additional source. Chemical and physical properties of the Tres Hermanos Sandstone and soils from the borrow site are discussed in the previous section.

Surface Disturbed Areas Reclaimed (485 acres)

Between 1976 and 1979, Anaconda Minerals Company conducted reclamation activities on 17 waste dumps, comprising approximately 485 acres. Refer to Table 1-4, Chapter 1 and for waste dumps reclaimed to date.

Surface Preparation

In general, many dump tops were contoured, numerous small depressions constructed for water harvesting, and a series of erosion control berms were developed. The dump surfaces were initially conditioned with overburden and alluvial material that tested suitable from chemical and physical laboratory evaluations.

Following topsoil placement, the dump surfaces were ripped to a depth of approximately 8-12 inches followed by a fine surface soil scarification. Organic mulching was performed with the addition of two tons per acre of barley straw and incorporated into the soil profile utilizing a Finn notched disc crimper. The areas were fertilized at an average rate of 30-50 pounds per acre of nitrogen (N), 30 pounds per acre of phosphorous (P_2O_5), and 30 pounds per acre of potassium (K_2O) relative to deficiencies in the disturbed soils.

Plant Selection

Plant species used in previous reclamation efforts were selected primarily on the following characteristics: drought tolerance, season of growth, temperature tolerance, salinity tolerance, soil texture adaptation, vigor, rate of establishment, longevity, seed mix compatibility and grazing potential. Legumes were also considered for their nitrogen fixing characteristics. Plant selections were also made from this group to conform with edaphic conditions particular to the Tres Hermanos Sandstone growth medium.

Mixtures of plant species used in previous reclamation efforts at the mine are given on Table 2-34. The seeding rates were developed with the aid and recommendations of the Grants Office of the Soil Conservation Service (SCS), utilizing base information from non-irrigated land and critical area seeding technical guides. All seed drilling rates represented in Table 2-34 are higher than those of conventional guidelines and equal or exceed the seeding rates recommended for planting critical areas by the New Mexico Interagency Range Committee and the SCS.

TABLE 2-34

SEED MIXTURES USED FOR RECLAMATION FROM 1976 THROUGH 1979

Common Name	1976		1977		1978-1979	
	Percent of Mixture	PLS[a] Mixture lbs./Ac.	Percent of Mixture	PLS Mixture lbs./Ac.	Percent of Mixture	PLS Mixture lbs./Ac.
Blue grama (Lovington)	30	1.05	25	.625	30	.9
Indian ricegrass (Paloma)	5	.4	10	.7	10	1.1
Fourwing saltbrush	0	—	5	1.8	5	1.5
Crested wheatgrass (Nordan)	0	--	15	1.2	0	--
Alkali sacaton	5	.4	15	.15	15	.25
Weeping lovegrass	10	.3	15	.15	15	.25
Sand dropseed	15	.15	10	.05	0	—
White clover	0	—	5	.1	0	--
Sideoats gramma	5	.7	0	—	10	1.8
Yellow sweetclover	0	—	0	—	5	.25
Western wheatgrass	5	1.0	0	--	10	2.4
Little bluestem (Pastura)	15	1.2	0	—	0	--
Sand bluestem	5	.8	0	—	0	—
Sweet clover	5	.4	0	--	0	--
TOTAL	100	6.4	100	4.78	100	8.45

Source: Anaconda Minerals Company 1982.

Note: [a]Pure Live Seed

In most situations, the seed mixture was planted with a rangeland drill. This type of machinery is adapted to rough and rocky terrain and is especially designed to operate efficiently in disturbed soil seeding environments.

Following seeding, barley straw was broadcast over the top of the seed and incorporated into the surface soil.

Revegetation Success

Sampling procedures and plant growth monitoring were conducted on an annual basis beginning in 1979 to include plant density (determined by the number of plants per species in one meter quadrant), and vegetative cover (measured by line intercept of a 30.5 meter transect line).

Reference areas were established on undisturbed areas around the mine area with vegetative types differing at the various locations. The areas were sampled for vegetative density, basal cover and botanical composition and were used for comparative purposes.

Success of vegetative establishment on the reclaimed areas relative to the reference areas is shown in Table 2-35. It should be noted that the reclaimed site cover and density figures were compared to an average reference site figure for cover and density.

Waste dumps S and J, reclaimed in 1976 and 1977, respectively, developed basal plant cover values that exceeded those of the native reference areas; therefore, monitoring studies were dropped in 1981 (Figure 2-16).

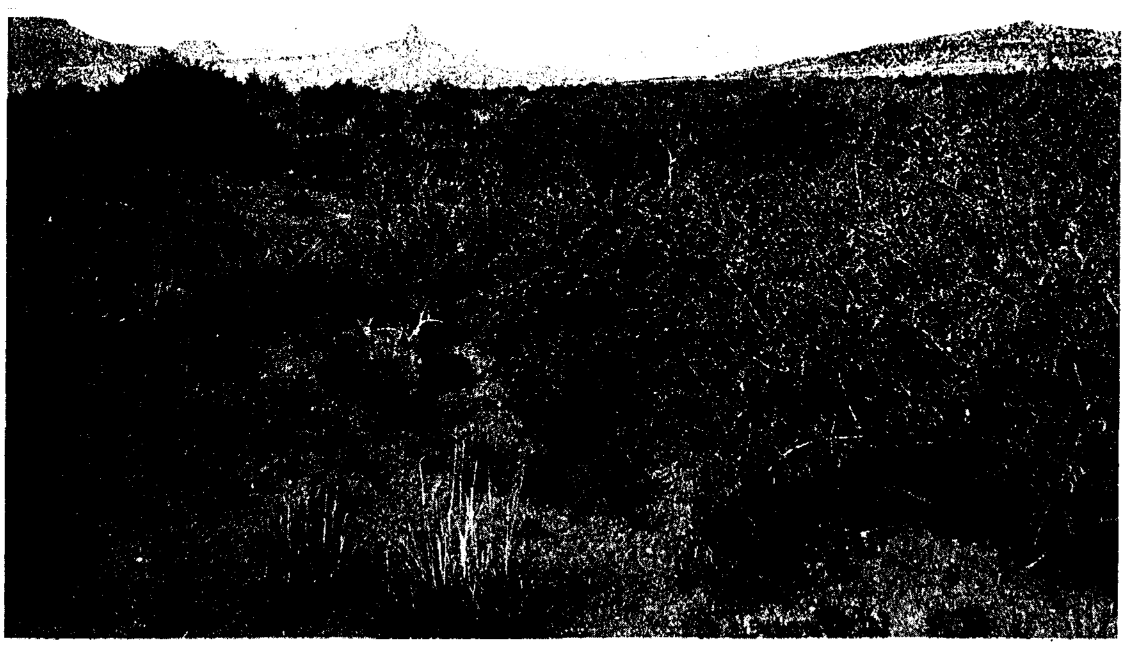

FIGURE 2-16 SUCCESSFUL REVEGETATION ON TOP OF S DUMP

TABLE 2-35

RECLAIMED SITE TO REFERENCE SITE COMPARISONS FOR BASAL COVER AND DENSITY

	1980				1981				1982			
Site	Percent Cover	Percent of Reference Site Ave.	Density - Plants/M^2	Percent of Reference Site Ave.	Percent Cover	Percent of Reference Site Ave.	Density - Plants/M^2	Percent of Reference Site Ave.	Percent Cover	Percent of Reference Site Ave.	Density - Plants/M^2	Percent of Reference Site Ave.
C, D, E[a]	2.62	59	23.1	32	4.38	71	55.66	69	3.70	60	48.28	71
F, G[a]	2.83	64	17.0	24	5.47	89	69.85	86	6.12	99	23.28	34
J[a]	6.49	146	60.75	85								
O, P, P1, P2[a]	3.87	87	25.75	36	4.82	78	88.75	110	5.46	88	107.0	158
S[a]	4.68	105	30.0	42								
X, I, Y2[b]					5.21	85	67.0	84	4.44	72	70.54	104
T[b]					4.05	66	76.66	95	4.25	69	107.0	158
L[b]					1.68	27	418.75	518	3.19	52	57.0	84
K[b]					2.14	35	694.32	859	3.66	59	110.33	163
Reference Site Average	4.45	100	71.5	100	6.16	100	80.83	100	6.17	100	67.74	100

Source: Ludeke 1983.

Note: [a]Reclaimed 1976-1977.
[b]Reclaimed 1978-1979.

Waste dumps F, G, J, O, P, P1 and P2 were seeded in 1977 and reflect basal cover values of approximately 90 percent of the average cover estimates collected from reference areas. Dump sites I, T, X and Y2 were seeded in 1979, and after completion of three growing seasons, are exhibiting basal cover percentages near 70 percent of the reference areas sampled. Numerous dump sites sampled in 1982 have exceeded 100 percent of the plant density represented by the reference areas. These include dumps C, D, E, I, K, O, P, P1, P2, X and Y2.

No quantitative data exists to assess the establishment of vegetation for reclamation attempts on steep dump slopes at the Jackpile-Paguate minesite. However, qualitative assessment indicates that almost no vegetation has been established on such slopes due to severe erosional problems and surface soil movement.

Table 2-36 lists levels of uptake of chemical and radiological constituents by plants on reclaimed sites. The heavy metal concentrations are below those generally considered to be toxic to livestock (5.0 parts per million).

FAUNA

Many wildlife species prefer specific habitat types. The four wildlife habitat types and the animals typically associated with them in the area of the Jackpile-Paguate uranium mine are:

1. Grassland-desert shrub: Coyotes, prairie dogs, rabbits, rattlesnakes, gophers and several bird species.

2. Juniper "savanna": Foxes, squirrels, chipmunks, porcupines and a large number of bird species.

3. Riparian: Toads, lizards, invertebrates, ducks and other birds.

4. Bare ground: Coyotes, prairie dogs, other rodents and lizards.

A complete list of species to be found within the vicinity of the minesite is on file in the BLM Albuquerque District Office, Rio Puerco Resource Area.

The mine environment itself does not support an abundant wildlife population. Big game species are generally absent, with no individuals sighted in recent years. The natural flow of the Rios Paguate and Moquino does not support fish populations in the vicinity of the mine, although the Rio Paguate above the minesite is classified by the State of New Mexico as a high quality coldwater fishery and is regularly stocked and fished. The existence of the mine places a restriction on wildlife presence. The larger, more mobile species tend to avoid areas of human activity, and the significant acreage of barren ground offers little for wildlife other than burrowing habitat for rodents and lizards.

TABLE 2-36

RECLAIMED SITE VEGETATION ANALYSIS

		Chemical[a]							Radiological[b]		
Sample Site	Date Taken	As	Se	Mo	Pb	V	Cd	Zn	Ra-226 (pCi/gm)	U-Nat. (ug/gm)	Th-230 (pCi/gm)
Dump J (R2)	7-17-79	0.25	1.0	0.7	1.2	1.0	0.1	25.0	1.59	1.02	0.53
Dump J (R4)	7-17-79	1.2	1.6	1.3	2.0	1.0	0.1	22.9	0.24	2.14	1.85
Dump S (Composite)	7-17-79	0.4	1.0	0.1	1.0	3.9	0.1	30.9	0.32	3.66	0.43
Dump S (R4)	7-27-79	0.4	1.0	0.1	0.5	3.0	0.1	35.0	0.28	1.76	0.52
Dump P1 (R3)	8-02-79	0.7	1.0	0.1	0.5	6.0	0.1	30.1	0.16	0.76	0.59
Dump C (R9)	9-24-80	0.3	0.07	0.7	0.5	0.9	0.1	32.0	1.15	7.13	1.17
Dump D (R8)	9-24-80	0.6	0.05	1.1	0.5	0.7	0.1	36.0	0.39	4.71	0.56
Dump E (R8)	9-24-80	0.7	3.0	0.7	0.5	0.8	0.1	57.0	1.14	5.37	2.56
Dump G (C4)	9-24-80	0.4	.49	0.1	0.5	0.5	0.1	43	1.02	2.89	0.84

Source: Anaconda Minerals Company.

Note: [a]All values are expressed in parts per million. As = arsenic; Se = selenium; Mo = molybdenum; Pb = lead; V = vanadium; Cd = cadmium; Zn = zinc.
[b]Ra = radium; U = uranium; Th = thorium.

Threatened and Endangered Species

Within the mine leases occur no species of plants or animals included on (or proposed for inclusion on) the list of endangered and threatened wildlife and plants. The bald eagle, peregrine falcon and black-footed ferret are species on the endangered list that could range in the minesite area; however, they would be transients. No known sightings have occurred, and the mine environment would not be a favorable one for these species. The U. S. Fish and Wildlife Service has determined that no listed or proposed species would be affected by the proposed reclamation of the Jackpile-Paguate uranium mine (letter dated May 12, 1981).

CULTURAL RESOURCES

The entire Jackpile-Paguate mine lease area has been archeologically inventoried, with a total of 217 archeological sites recorded (Anschuetz, et al. 1979; Beal 1976; Carroll and Hooten 1977; Carroll, et al. 1977; and Grigg, et al. 1977). Of this total, 205 remain. Seven of the sites were excavated, and five were formally determined to be insignificant prior to their destruction by mining. These sites demonstrate that the mine area has been intermittently utilized since the Archaic period (approximately 5,000 B.C.).

The archeological sites range in date and size from Archaic scatters of chipped stone to Basketmaker (A.D. 400-700) pit house villages and Pueblo (A.D. 700-1600) stone masonry rooms. Many sites of modern trash and structures associated with recent sheepherding activity have also been recorded. Four of the archeological sites are also of religious concern to the Pueblo of Laguna.

Access to archeological sites on the mine leases is presently controlled by Anaconda Minerals Company to protect them from vandalism.

VISUAL RESOURCES

The Jackpile-Paguate uranium mine site consists of 2,656 acres of disturbance surrounded by natural relief features including plateaus, mesas and valleys typical of much of the southeastern Colorado Plateau physiographic province.

Mining operations caused substantial changes to the natural landform, line, color and texture, resulting in a dominant, unnatural appearance. Along with the reshaping of the landform within the minesite, the stream channels of the Rios Paguate and Moquino were modified from their natural meandering conditions. The contrast between the minesite and its surrounding has degraded the visual resources in the general area.

Ninety percent of the disturbed acreage from the minesite consists of waste dumps and open pits. The majority of the dumps are relatively flat-topped with steep-sided slopes, a basic form that is characteristic of the surrounding mesas. However, these new man-made landforms exhibit a lighter surface coloration and smoother texture than the surrounding landscape. Thus, the concentration of these dumps, along with their distinct difference in color and texture, create a setting that contrasts with and dominates the surrounding landscape. It should be noted that previous reclamation efforts by Anaconda have enhanced the visual resource qualities of several waste dumps.

The three open pits at the minesite consist of large depressions with steep highwall slopes. The depressions vary in depth, with the deepest being the Jackpile pit (625 feet). The open pits are partially filled with water as a result of ground water seepage and surface runoff. These deep depressions and surface water bodies contrast sharply with the surrounding landscape.

The site also contains approximately 50 buildings in five main areas. These buildings were used for office space, equipment repair, shops, employee housing and storage. Many of these buildings are larger than other structures common to this rural area. Their size and the use of sheet metal siding have resulted in a prominent landscape feature.

SOCIOECONOMIC CONDITIONS

The Pueblo's economic base shifted from agriculture to mining in the early 1950's, and with the Jackpile mine's closing, little economic base remains.

Employment

Employment at the Jackpile-Paguate mine reached 700 to 800 persons in the early 1970's. The vast majority of mine workers were Laguna Indians with some non-Indians from the Spanish land grant immediately north of the mine and adjacent to the reservation. Permanent closure of the Jackpile mine affected 726 workers in the Cibola County labor market area, including 513 Pueblo workers. A survey taken in November 1980 by the Council of Energy Resource Tribes (CERT) estimated that 101 of the 513 workers were no longer in the local workforce. However, 412 workers were left without jobs and probably have not found new employment (CERT 1983a).

Employment data for Valencia County, and for Cibola County since its creation from Valencia County in 1981, show employment trends generally representative of the area. In Valencia County, employment in metals mining was 2,076 in the first quarter of 1977. It rose to 3,141 in the third quarter of 1980, and then declined to 415 in the first quarter of 1983 (Table 2-37). No metals mining employment has been reported for

TABLE 2-37

NUMBER OF PEOPLE EMPLOYED IN THE MINING INDUSTRY,
VALENCIA AND CIBOLA COUNTIES
(By Quarter, 1977 to 1983)

Year	Quarter	County	Employment			
			Total	Metal	Oil and Gas	Non-Metal
1983	1	Cibola & Valencia	503	415	--	--
1982	4	Cibola & Valencia	708	624	--	--
	3	Cibola & Valencia	769	682	--	--
	2	Cibola & Valencia	1,381	1,296	--	--
	1	Cibola & Valencia	1,706	1,616	--	--
1981	4	Cibola & Valencia	2,063	1,970	--	--
	3	Cibola & Valencia	2,527	2,430	--	--
	2	Valencia	2,937	2,832	--	--
	1	Valencia	3,101	3,011	--	--
1980	4	Valencia	3,155	3,064	--	--
	3	Valencia	3,235	3,141	--	--
	2	Valencia	3,222	3,138	--	--
	1	Valencia	3,193	3,107	--	--
1979	4	Valencia	3,122	3,048	--	--
	3	Valencia	2,925	2,849	--	--
	2	Valencia	2,788	2,709	--	--
	1	Valencia	2,692	2,578	--	--
1978	4	Valencia	2,719	2,555	147	17
	3	Valencia	2,711	2,552	153	--
	2	Valencia	2,304	2,158	134	12
	1	Valencia	2,528	2,357	--	--
1977	4	Valencia	2,469	2,316	147	--
	3	Valencia	2,455	2,311	137	--
	2	Valencia	2,296	2,194	95	--
	1	Valencia	2,155	2,076	73	--

Source: New Mexico Employment Security Department 1983.

the present Valencia County area since the second quarter of 1981, indicating that metals mining prior to that time was taking place in the area formed by the new Cibola County.

Table 2-38 shows a decreased labor force in the area, indicating that some people have moved away. However, it also shows a very high unemployment rate (25.6 percent for Cibola County), indicating that many of those who have been laid off in mining or mining-related jobs remain in the area. The Lagunas' cultural traditions and desire to live and work on the reservation have prevented many of them from taking jobs available elsewhere.

The total number of people in the Pueblo of Laguna's labor force is estimated to be 1,200, with the unemployment rate reported to be over 50 percent (CERT 1983a). Laguna efforts to attract industry to replace the jobs lost when the Jackpile-Paguate uranium mine closed have been only partially successful.

Income

Current reliable income figures for the Pueblo are not readily available. However, figures presented by CERT (1983a) show the median income of Lagunas to be less than half of the median income of New Mexicans in 1950 and 1960. By 1970, the median income reported by the Lagunas was $2,661, just under 75 percent of the median income reported by other New Mexicans.

In addition to employment income, foodstamps were reported by CERT to have supplemented cash income for 69 households, with pensions and welfare being other sources of income. The non-wage sources of support are probably much higher since the mine's closing, although current figures are not available.

The major sources of income for the Laguna and Acoma reservations in 1978 are shown in Table 2-39.

The Anaconda shutdown reduced the Laguna-Acoma total annual income by an estimated $8 million. The Sohio uranium mine is also closed (at least temporarily), and the loss of these two sources of income have reduced the total income shown in Table 2-39 by approximately 70 percent.

Social Problems

For nearly 30 years the Pueblo of Laguna depended almost exclusively on the Jackpile-Paguate uranium mine for employment. As typical of any area dominated by one employer, the mine closure had a major impact on the Pueblo of Laguna. The sudden loss of income caused the Laguna people to readjust their standard of living. Along with this readjustment came a variety of social problems including increased alcohol and drug abuse, and increased social work and family counseling caseloads (CERT 1983b). These problems can be expected to persist until the Pueblo of Laguna can diversify its economic base and subsequently reduce unemployment.

TABLE 2-38

LABOR FORCE AND EMPLOYMENT FIGURES, VALENCIA AND CIBOLA COUNTIES
(Selected Dates)

Month	Year	County	Labor Force	Employed	Unemployed	Unemployed Rate
July	1983	Cibola	12,102	8,999	3,103	25.6
July	1983	Valencia	10,373	9,092	1,281	12.3
July	1982	Cibola	12,765	9,821	2,944	23.1
July	1982	Valencia	11,477	10,073	1,404	12.2
Jan.	1982	Cibola	11,714	10,217	1,497	12.8
Jan.	1982	Cibola	11,449	10,321	1,128	9.9
July	1981	Valencia	25,174	22,536	2,638	10.5
July	1980	Valencia	25,682	23,348	2,334	9.1
July	1979[a]	Valencia	25,696	24,059	1,637	6.4
July	1978	Valencia	24,095	22,729	1,366	5.7
July	1977	Valencia	20,430	18,702	1,728	8.5

Source: New Mexico Employment Security Department 1983.

Note: [a] Preliminary figure used because no revised figure was available.

TABLE 2-39

MAJOR SOURCES OF INCOME - LAGUNA AND ACOMA RESERVATIONS (1978)

Employer	Number of Employees	Total Payroll	Average Annual Income
Anaconda Corporation	680	$11,492,000	$16,900
Sohio	270	4,744,000	17,570
Indian Health Service	100	1,941,229	19,412
Bureau of Indian Affairs	100	1,478,393	14,784
Laguna Tribal Programs	350	2,461,017	7,031
Others (estimated)	120	1,100,000	9,167
TOTAL	1,620	$23,216,639	$14,331

Source: Council of Energy Resource Tribes 1983a.

Chapter 3
environmental consequences

INTRODUCTION

Chapter 3 presents discussions of the environmental consequences which would result from implementation of the reclamation proposals. This chapter also presents the scientific and analytic basis for comparison of the reclamation proposals described in Tables 1-3, 1-4 and 1-5, Chapter 1.

BLASTING DURING RECLAMATION

The No Action Alternative would require no blasting. Except for Anaconda's Proposal, the other reclamation alternatives may use blasting to reduce pit highwalls or to construct the Jackpile pit drainage channel under the DOI Drainage Option.

The major adverse effects of blasting would be ground vibration and airblast. Both of these effects could cause annoyance to village residents and structural damage.

Ground vibration is usually described as the velocity of a particular point or particle in the ground (particle velocity), and it is expressed in inches per second (in/s). Airblast is an air overpressure generated by an explosive blast and resulting rock breakage and movement. It is commonly expressed as a relative sound level in decibels (dB) in a particular frequency range or frequency weighting that is measured in hertz (Hz).

While ground vibration and airblast are dependent on numerous factors (e.g., geology, distance from blast, weight of explosive, blast confinement and weather), blasts can be designed to minimize their magnitudes and any resulting effects. It is generally accepted that ground vibration less than 0.5 in/s and airblast in the range of 100 to 120 dB reduce annoyance and do not cause structural damage, depending on specific site characteristics (Siskind, Stachura, et al. 1980; Siskind, Stagg, et al. 1980).

The U.S. Bureau of Mines (USBM) has reviewed and evaluated blasting data for the Jackpile-Paguate uranium mine, previous reports on the effects of the blasting, and the blasting uses and locations proposed in the reclamation alternatives. Based on this review and evaluation, as well as previous studies on ground vibration and airblast, the USBM has made recommendations for controlling the effects of blasting during reclamation (USDI, Bureau of Mines 1983a and b).

1. The Village of Paguate should be inspected prior to blasts. Frequent and detailed inspections of one or a limited number of structures would be useful as a control measure.

2. Ground vibration, airblasts and cosmetic damage to structures should be monitored. Initial blasts should be designed for the following limiting values:

   a. Maximum ground vibration of 0.2 in/s, and
   b. Maximum airblast of 125 dB (5 Hz high pass) or 128 dB (2Hz high pass).

If initial tests show that damage to structures does not occur at these values, levels could probably be increased to 0.5 in/s and by 3dB. However, this would likely produce increased numbers of complaints alleging damage. Actual damage is unlikely but this cannot be guaranteed.

The resulting monitoring data could be used to define certain site characteristics that would provide more flexibility in the design of the blasts. Ground vibration should be monitored with velocity-measuring seismographs having a frequency response of 5 to 200 Hz.

3. A test should be conducted to determine if the minimum charge delay of 9 milliseconds is sufficient, particularly for the blasts farthest from the Village of Paguate.

4. When the wind is blowing from the south, southeast or east, blasting should not be conducted unless the blasts are designed for sufficient confinement to avoid the likely increased airblast.

MINERAL RESOURCES

Introduction

The Jackpile-Paguate uranium mine was closed because extraction of the uranium deposits was no longer economic. The entire deposit was not mined, and improved market conditions, better technology, or different economic circumstances could make future mining profitable. Protore was stockpiled for use in blending or possible heap-leaching. Additional mining and/or heap leaching are not considered viable at this time or in the foreseeable future.

The following general conclusions have been reached regarding the remaining uranium resources at the minesite:

1. The protore has significant potential value to the Pueblo of Laguna as long as it remains readily accessible.

2. The P-10, Alpine and H-1 mines were depleted of economic reserves. The P-15/17 mine was approved for development but never begun.

3. The resources in the P15/17, NJ-45 and P-13 underground deposits have significant potential value to the Pueblo.

4. The value of the NJ-45 and P-13 deposits would decrease if their adits and drifts are rendered inaccessible.

No Action Alternative

Protore would remain accessible for a period of time. However, normal erosive processes would operate on all of the protore piles located outside the pits, and cause significant losses of these resources over many decades.

A portion of Gavilan Mesa highwall would probably collapse on top of protore piles JLG, J-1A, J-1-A and SP-1 which presently serve as a buttress at the base of the highwall. These piles contain approximately 1.7 million cubic yards of protore. Future recovery of this buried material would be uneconomical except under the most favorable conditions.

The NJ-45 and P-13 underground deposits would be accessible through existing workings. However, this alternative does not provide for maintenance of these areas. Therefore, the workings would deteriorate over time making them unsafe and inaccessible. This would make it more costly to reopen these areas as time progresses.

Green Book Proposal

Under this alternative, all protore would be placed in the open pits. This would totally eliminate the erosion impacts as described under the No Action Alternative.

Additional buttress material would be placed at the base of Gavilan Mesa. However, the upper portion of the highwall above the buttress could eventually fail and cover the material below. Future recovery of this buried material would be uneconomical except under the most favorable conditions.

Future production of underground deposits would require either the reopening of old adits or construction of new openings. However, these costs would be small in comparison to overall production costs.

DOI Proposal (Both Options)

This alternative would cause the same impacts as the Green Book Proposal except that there would be less of a chance of Gavilan Mesa collapsing on the buttress material because the highwall would be contoured to a more natural profile following the existing joints in the rocks.

Laguna Proposal

Under this proposal, all protore would be placed in the open pits and segregated according to grade. Future recovery of this material would be enhanced since the final location and thickness of the low-grade and high-grade protore would be surveyed and plotted on maps for future reference. Placement of protore in the open pits would eliminate the erosion impacts as described under the No Action Alternative.

No additional buttress material would be placed at the base of Gavilan Mesa. The impacts to the underground deposits would be the same as the Green Book Proposal.

Anaconda Proposal

In the short-term, recovery of the protore would be simplified since only 12 inches of topsoil would cover the protore piles. However, over the long-term, erosion and lateral migration of the Rios Paguate and

Moquino could cause significant loss of the protore into these two perennial rivers. In addition to the long-term loss of the mineral resource, there could be other adverse environmental impacts as discussed in other parts of this chapter.

No additional buttress material would be placed at the base of Gavilan Mesa. The impacts to the underground deposits would be the same as the Green Book Proposal.

Preferred Alternative

The impacts to protore and underground deposits would be the same as the Green Book Proposal. No additional buttress material would be placed at the base of Gavilan Mesa.

NON-RADIOLOGICAL HAZARDS

Highwall Stability

No Action Alternative

Under this alternative, the stability of highwalls would be the same as analyzed in Chapter 2. The North Paguate pit highwall would be stable and the South Paguate pit highwall would probably be stable over the long-term (hundreds of years) except for the usual loose or overhanging blocks. The alluvial cover on the highwall crests could slump or erode by piping. Any small rockfalls or alluvial slumps could be hazardous to humans and livestock. However, the probability of someone being underneath a highwall at the exact moment of failure is extremely low.

Under present conditions, the Gavilan Mesa highwall is probably very close to a state of limiting equilibrium; that is, it may be just on the verge of failure and is almost certainly unstable for the longterm. The highwall would probably undergo a large rotational failure which could be hazardous to humans and livestock. Again, the chance of such failure occurring while humans or livestock are present is extremely low.

Over the long-term, all highwalls at the minesite would approximate the geometry and stability of surrounding natural cliffs, i.e., sandstone slopes would be vertical, and shale slopes would approach 30 degrees.

The highwalls would remain an attractive nuisance, especially for young people. Anyone approaching the edge of the highwalls could accidentally fall off. Although there have been few reports of people going near the highwalls, this safety hazard would still exist. Continuation of existing security measures (i.e., limited fencing, locked gates and patrols) would not be sufficient to prevent persons from entering the minesite and going near the highwall crests. This potential hazard would be greater at South Paguate pit highwall due to the lack of fencing along the rim and its proximity to State Highway 279 (present location). North Paguate pit highwall would be less hazardous due to the presence of fencing and even though Gavilan Mesa is not fenced, it would also be less hazardous due to its relatively isolated location within the minesite.

Green Book Proposal

Scaling of the highwalls would reduce the amount and frequency of rockfalls for the short-term and thereby reduce the hazards to humans and livestock. Over hundreds of years, rockfalls would approach the amount, size and frequency of rockfalls on nearby natural cliffs. The alluvial cover on the North and South Paguate pit highwalls could slump or erode by piping. These alluvial slumps could be hazardous to humans and livestock.

The proposed Green Book stabilization measures for Gavilan Mesa would not significantly increase the overall stability of the highwall or blend the highwall into the natural surrounding. The planned buttress would stabilize the lower portion of the highwall but would do nothing for any potential failure surface which daylights above the top of the buttress. The alternate method of removing the upper portion of the highwall, by either blasting or hauling, would not significantly increase the stability of the highwall (Figure A-6, Appendix A). It would result in higher unbenched slopes with the upper part of the highwall not much flatter than the existing slope. In all, a significant safety hazard would still exist.

The potential hazard for people falling off the highwalls would be the same as described under the No Action Alternative.

DOI Proposal (Both Options)

The impacts of scaling the highwalls would be the same as the Green Book Proposal. Under this alternative, the upper 10 feet of alluvial material at the pit highwall crests would be sloped 3:1 to prevent slumping and piping (Figure A-7, Appendix A). This measure would reduce the risk of injury to humans and livestock below the highwalls.

Based on observations of natural buttes and mesas in the vicinity of the Jackpile - Paguate mine, it was concluded that it is not feasible to reclaim the Gavilan Mesa highwall to a state of absolute stability. The measures proposed under this alternative would reshape the Gavilan Mesa highwall to conform to the surrounding natural slopes as closely as possible; that is, approximately 30 degree slopes in the shale intervals and nearly vertical slopes, following natural joints, in the sandstone beds, with some benches (Figure A-6, Appendix A). Two vertical joint sets, striking N. 25° E. and N. 35° W., have been identified in the Gavilan Mesa highwall (Seegmiller 1979a). In plan view, the highwall would follow these joint directions as closely as possible. This modification, including the planned buttress, would increase the safety factor of the highwall to 1.4. Besides blending the mesa into the natural surrounding, these measures would increase the stability of the highwall and thereby reduce the safety hazard compared to the Green Book Proposal.

The proposed fencing for the South Paguate pit highwall and any realignment of the existing North Paguate highwall fence would not totally preclude access to the rim of the highwalls, but would serve as a deterrent, especially for young children and the curious.

Laguna Proposal

The impacts of scaling would be the same as the Green Book Proposal. In addition, the top 15 feet of each highwall would be cut to a 45 degree slope and any alluvial material remaining at the top of the cut would be recontoured to a 3:1 slope (Figure A-7, Appendix A). This measure would reduce the risk of injury to humans and livestock below the highwalls.

The impacts of fencing the South and North Paguate pit highwalls would be the same as the DOI proposal.

Anaconda Proposal

For the Jackpile and North Paguate highwalls, the pit wall crests would be scaled 10 feet back at 3:1 (Figure A-7, Appendix A). This proposal would provide less safety from rockfalls since the face of the highwalls would not be scaled.

The potential hazard for people falling off the highwalls would be the same as described under the No Action Alternative.

Preferred Alternative

Pit highwall treatments and corresponding impacts would be the same as the Laguna Proposal. In addition, a monitoring program would be implemented to detect future areas of instability. Unstable portions of the highwall would be repaired as needed by scaling or other appropriate methods.

Waste Dump Stability

No Action Alternative

Under this alternative, it is probable that rotational slope failures would occur on FD-2 and V dumps. FD-2 could also exhibit base translational failure.

If FD-2 dump were to fail, a slump would probably displace the upper one-third to one-half of the dump, with the displaced material falling to the blocked drainage at the base.

V dump is located approximately 500 feet northeast of the confluence of the Rio Moquino and Rio Paguate, and at one point is within 300 feet of the Rio Moquino. A massive failure of V dump could result in damming of the Rio Moquino, while a small failure would probably cause a greatly increased sediment load in the streams.

For the short-term (that is, the dump materials exhibit some cohesion), the rest of the waste dumps at the minesite would be stable. However, experience has shown that cohesion is not an effective agent for holding up a slope over the long-term.

To assess the long-term stability of all waste dumps at the minesite, the DOI (Smith 1982) estimated safety factors for dry, cohesionless slopes. These calculations indicated that a 2:1 slope would have a safety factor of 1.06; a 2.8:1 slope would have a safety factor of 1.5; and a 3:1 slope would have a safety factor of 1.6. A 2:1 slope would only be marginally stable over the long-term, while a 3:1 slope should give an adequate margin of safety against mass failure. Since virtually all of the waste dumps at the minesite exhibit slope angles greater than 2:1, they could eventually fail. These failures could result in blockage of natural drainage channels, alteration of stream courses and increased sediment load (including radioactive materials) in the streams.

Green Book Proposal

Under this alternative, most waste dumps would be sloped steeper than 3:1 with intermediate slopes ranging up to 2:1. A system of terraces, berms and rock-lined drainage structures is also planned as part of the slope modification (Table 1-4, Chapter 1).

The steep intermediate slopes do not meet the safety factor criteria of 1.5 or greater. These intermediate slopes could therefore fail over the long-term. The dumps proposed for overall slopes of 2:1 or steeper include: C, D, E, F, G, K, O, P, P1, P2, part of S, parts of T and W. These dump slopes would have a safety factor of less than one and therefore would be unstable over the long-term. Dumps proposed for overall slopes less than 2:1 but steeper than 3:1 include: FD-1, FD-2, FD-3, I, N, N2, South Dump, part of T, U, V, Y and Y2. These dump slopes would be marginally to probably stable. Dumps proposed for overall slopes of 3:1 or more gentle include: A, B, L, Q, R and the southern part of S dump. These dump slopes would be stable for the long-term.

DOI (Both Options) and Laguna Proposals

Under these alternatives, most dumps would be sloped 3:1 or flatter with no terracing. All dumps sloped 3:1 would have a safety factor of 1.6 and would therefore be stable over the long-term. The 3:1 slopes and contour furrowing would virtually eliminate the hazards resulting from mass failure as described in the No Action Alternative and Green Book Proposal.

Under the DOI Proposal, waste slope modifications for dumps FD-2, I and Y2 would yield overall slopes steeper than 3:1 because of physical restrictions and constraints with earth moving activities. For the Laguna Proposal, dump FD-2 would have an overall slope steeper than 3:1. Although the slopes would be steeper than 3:1, the proposal modifications would make them more resistant to rotational failure than under the No Action Alternative.

Anaconda Proposal

Dumps sloped 3:1 would be stable. Dumps steeper than 2:1 would be only marginally stable and could eventually fail resulting in the impacts listed under the No Action Alternative. These dumps include: C, D, E, F, FD-1, FD-2, G, K, O, P, P1, P2 and South Dump.

Preferred Alternative

All dumps, except FD-2, would be sloped 3:1 and would be stable over the long-term. FD-2 would be probably stable over the long-term.

Subsidence

No Action Alternative

Under this alternative, the possibility exists that the ground above the P-10 mine decline could experience subsidence of significant magnitude and rate. A sudden change in ground elevation could result in injury to humans and livestock standing immediately above the decline area. All other areas above underground workings are in a low risk category with regard to subsidence and therefore do not pose a hazard.

Green Book, DOI (Both Options), Laguna, Anaconda Proposals and Preferred Alternative

The P-10 mine decline would have a cement bulkhead placed approximately 680 feet below the surface opening. The decline would then be backfilled from the bulkhead to the surface with overburden material. This measure would eliminate the subsidence hazard above this area. All other underground workings would pose no subsidence hazard as described under the No Action Alternative.

Underground Openings

No Action Alternative

Six adits, one decline and 20 vent holes are presently open at the minesite. These openings present a physical hazard in that people or livestock could use them to access unstable underground workings. These areas could also contain elevated levels of radon and radon daughter products and thus pose a localized radiological hazard.

Green Book, DOI (Both Options), Laguna, Anaconda Proposals, and Preferred Alternative

Under these alternatives, all underground openings would be backfilled and/or bulkheaded so no entrance to the underground workings would exist. This measure would totally eliminate the hazards described under the No Action Alternative.

RADIATION

NOTE: Due to time constraints and the complexity of the analysis, it was not possible to include a post-reclamation radiological impact analysis for Anaconda's 1985 Multiple Land Use Reclamation Plan and the revised Laguna Proposal. For Anaconda's 1985 Plan, DOI believes that the minimal soil cover would result in the minesite reverting to conditions approaching the No Action Alternative. The impact of the revised Laguna Proposal would essentially be the same as the original Laguna Proposal analyzed in the Draft EIS.

In response to public comment received on the DEIS, DOI reviewed the report prepared by Argonne National Laboratory (ANL/ES-131). The principal author, Dr. M. Momeni, commented on portions of the document. These comments are included in Appendix C and corresponding changes have been made to this section of the EIS.

Post-Reclamation Radiological Impacts

Introduction

The steps for evaluating the potential radiological impacts of each of the reclamation alternatives were as follows: 1) identify the sources of radiation; 2) define and delineate the pathways by which various components of the environment, especially humans, could be exposed to that radiation; 3) estimate the rates at which radioactivity is released along those pathways; and 4) use these estimates to calculate the total radiation exposure to the population of concern. The analyses were limited to the area beyond the minesite boundary and up to an 80 kilometer (km) radius.

The primary sources of radiation at the Jackpile-Paguate minesite are the radioactive isotopes formed by the decay of uranium-238 in the remaining ore and waste materials at the site. Specifically, these are: uranium-238, uranium-234, thorium-230, radium-226, radon-222, lead-210, polonium-210, bismuth-214, and lead-214. Although other sources of radiation exist, the amount of radiation emitted at the minesite from these other sources is so small in comparison with radiation from the uranium-238 series that the other sources need not be considered here. A more detailed description of the sources of radiation at the minesite is provided in Chapter 2.

The principal pathways by which people may be exposed to radiation from the minesite are: 1) direct external exposure to radiation emitted from radioactive material in the air and on the ground; 2) internal exposure to radiation from radioactive material inhaled into the lungs; and 3) internal exposure to radiation from radioactive material ingested with drinking water and foodstuffs. These exposure pathways are shown diagrammatically in Figure 3-1.

The reclamation alternatives being considered for the minesite could variously affect the potential for, and amount of, human exposure to radiation along these pathways. Therefore, the possible radiological

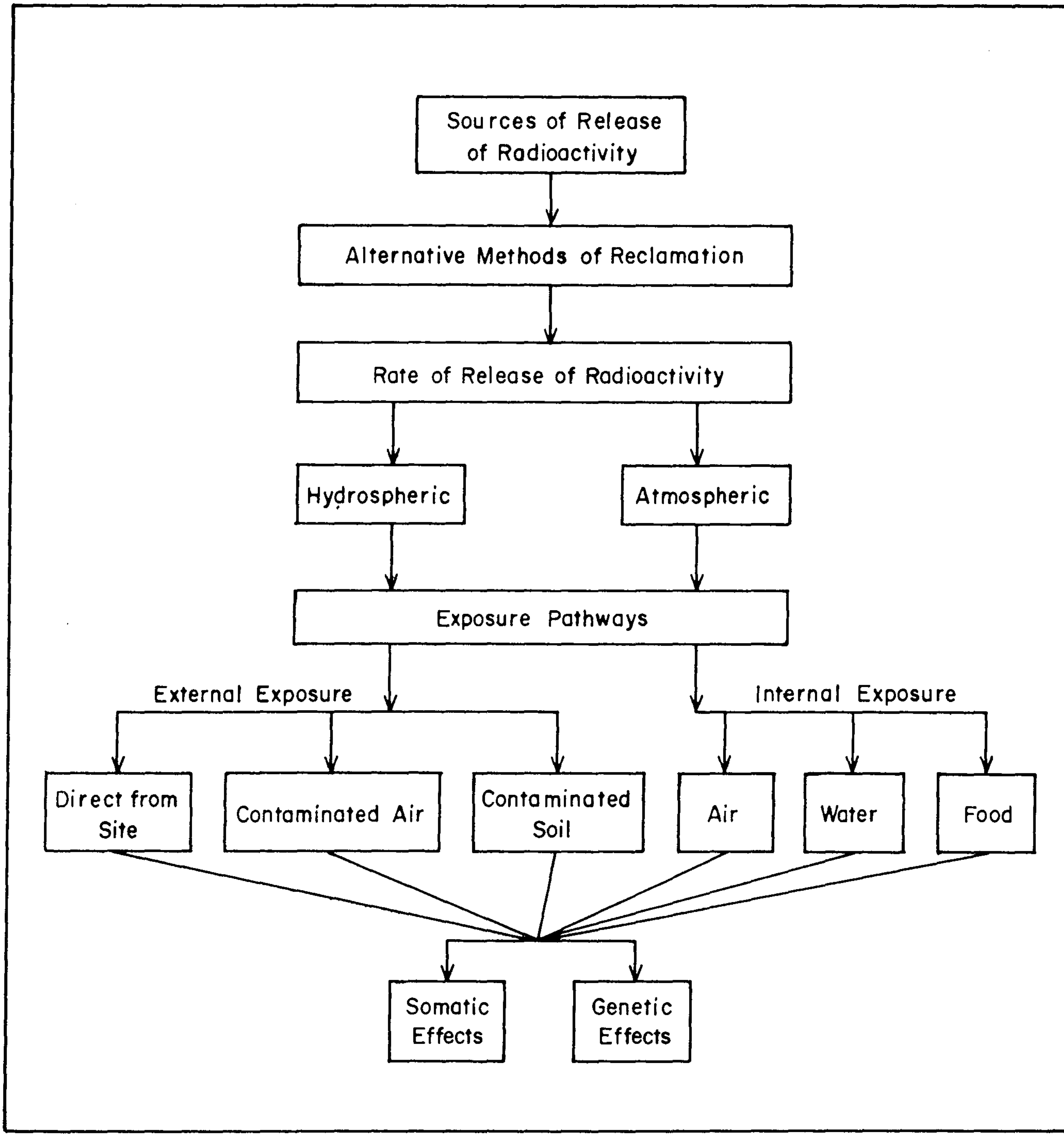

FIGURE 3-1

Potential Routes of Release of Radioactive Materials and Subsequent Exposure Pathways.

Source: Momeni, et al. 1983.

impacts of the reclamation alternatives have been evaluated with regard to: 1) calculation, for each alternative, of potential radiation doses that might be received by the general population after reclamation, and 2) conversion of these doses into possible numbers of radiation-induced health effects. The population groups considered in these evaluations are those people living near the boundaries of the minesite, and the entire population living within a 50-mile (80-kilometer) radius of the minesite following reclamation.

The potential radiological impacts summarized in this section are based on detailed evaluations presented in a report prepared by Momeni, et al. (1983) and revisions to that report by the principal author (May 1986). The evaluations in that report are based on data obtained from Anaconda Minerals Company, the U.S. Department of the Interior, published reports and other sources. A computer code--the Uranium Dosimetry and Dispersion (UDAD) Code--developed at Argonne National Laboratory (Momeni, et al. 1979) was used to calculate the radiation release rates, exposure rates and doses that form the basis of this radiological impact evaluation.

Assumptions

The mathematical models used to analyze radiological impacts require that a number of assumptions be made concerning basic physical, chemical and physiological processes that occur along radiation exposure pathways. These assumptions are used with data on radiological and environmental conditions at the site to make the calculations required for impact analysis. Some of the assumptions made in the evaluation of potential radiological impacts of the Jackpile-Paguate mine reclamation alternatives are outlined below.

Two basic sources of release of radioactivity to the air from the Jackpile-Paguate minesite have been identified: 1) distribution of radioactive particulates (contaminated dust particles) as a result of wind erosion of contaminated surfaces, and 2) diffusion of radon-222 gas from contaminated material into the air. The estimated rates of distribution of particles less than 100 microns in size from the minesite to the air have been calculated with the wind erosion formulas incorporated into the UDAD Code (Momeni, et al. 1979). The effect of soil surface creep from the minesite onto adjacent land and communities or run-off from contaminated watershed surfaces into impounded waters or reservoirs were calculated. It was assumed that airborne radioactive particles and sands would be distributed in the air only under the No Action Alternative. Under the other alternatives, the minesite would be covered with a layer of uncontaminated soil, and although wind erosion would not be eliminated, the radioactive material at the site would not be exposed to wind erosion so long as the soil cover remained intact.

Evaluation of the diffusion of radon-222 gas (formed by the radioactive decay of radium-226, which is a solid) involves consideration of a factor known as "specific flux". This is the amount of radon-222 released from a given area of the ground over a given time for each unit concentration of radium-226 in the soil.